IFE systems are evolving together with external connectivity systems. Airlines now have a range of IFE systems to choose from. The cabin entertainment and IFE equipment strategies of several airlines are examined here, with respect to on-board services and the hardware used.

Airline IFE system & cabin connectivity strategies

The development of different standards of in-flight entertainment (IFE) systems away from the traditional embedded systems has led airlines to follow different strategies when selecting their IFE and related cabin connectivity systems. A review of several airline case studies reveals the different ways of structuring cabin entertainment systems. These case studies also show how some airlines are upgrading their on-board services as a result of the continuing increase in IFE and external cabin connectivity system standards.

Airline choices

The simplest and cheapest IFE configuration available to airlines is an unconnected, standalone system that provides passengers with tablets pre-loaded with audio, visual and gaming content. This IFE system requires little or no additional hardware on board the aircraft, and no external cabin connectivity system. This type of system is suitable for airlines that need to offer some level of on board service for passengers, while minimising the initial installation and on-going operating costs.

At the opposite and top end of the scale, the most luxurious IFE systems have dual screens, content transmitted by hardwire connection or wirelessly, in-cabin WiFi with transmission rates to seats of up to 450 mega bits per second (Mbps), remote controls, and in-seat power outlets for passengers' personal electronic devices (PEDs).

There are several levels of IFE specification and standard in between these two extremes. Many airlines are now providing cabin WiFi, so they are also equipping their aircraft with external connectivity satcom systems to provide internet access in the cabin. Many airlines are moving away from traditional embedded systems, and equipping their fleets with wireless systems that use servers and tablets placed in seatback racks and holders. A growing number of short- and medium-haul airlines are using the combination of a connected cabin with a wireless IFE system and tablets.

Airlines seeking to minimise initial costs of IFE systems are providing cabin WiFi and installing IFE servers, but rely on passengers accessing the available content through PEDs via internal WiFi connectivity. These bring-your-own-device (BYOD) systems require passengers to download the airline's application on to their PEDs, usually on a complimentary basis.

Hybrid IFE systems have also evolved, and they combine aspects of the main categories have emerged. A hybrid version of the standard BlueBox Ai system. The hybrid version is configured to connect to approved third-party wireless streaming systems, which would increase the content over the pre-loaded material.

One type of hybrid is a standalone, pre-loaded system coupled with cabin WiFi so that passengers can use their PEDs to access the internet.

Another type of hybrid involves airlines using a combination of embedded and wireless systems, with tablets and external connectivity for the wireless segment of the system to provide several levels of entertainment, including on-line shopping through the tablet. They also have in-seat electrical ports for passengers to charge their PEDs which can be used for internet functions, such as e-mailing and web surfing on PEDs. The embedded part of the system can be used to provide an audio and visual on-demand (AVOD) service, as well as live TV and games.

The content available to passengers on both embedded and wireless systems is constantly increasing. The solid state disks on wireless IFE system servers now have a capacity of 3-4 terabytes (TB), so several hundred films can now be available, as well as more complex gaming.

Airlines have to be aware of licensing laws and to offer early window (EW) or late window (LW) content when choosing between embedded and wireless with airline-owned tablet IFE systems, and wireless BYOD systems. EW content mainly includes recent film releases at cinemas, while LW content is older. Only LW content can be streamed to PEDs, while EW content is permitted on embedded seatback screens and airline-owned wirelessly connected tablets.

Connectivity standards

While standalone or pre-loaded systems offer the simplest and cheapest solution for in-cabin service, passengers' expectations for free WiFi connectivity in the cabin are rapidly growing. The past seven to eight years have seen some airlines provide cabin connectivity on a paid-for basis, with limited success and low take-up rates.

New-generation and new satellite communication (satcom) systems are gradually increasing data transmission downlink rates to aircraft, and so are increasing the levels of on-board service that airlines are able to offer. Passengers' expectations that free WiFi with high data transmission rates will be available on board, are driving more airlines to acquire new-generation external connectivity satcom systems that provide

The highest specification IFE systems often include dual screens, remote control, live and pre-programmed TV shows, several hundred hours of on-demand audio and visual content, cabin WiFi, and in-seat ports for charging PEDs.

higher data downlink rates to the aircraft.

The inherent problem with first- and older-generation satcom systems is that their low data transmission rates can only cope with a small number of passengers being simultaneously connected to the internet. These systems included Ku-band satcom systems and the first generation of Gogo's air-to-ground (ATG) system in North America. These have transmission rates to the aircraft of 2-3Mbps.

By charging relatively high rates, such as $8 per flight or per day, airlines have had take up rates of less than 10%. Some may charge for internet connectivity to minimise take-up rates, in order to limit the disruption to on-board service levels.

Airlines such as jetBlue, Virgin America and Norwegian have led the way in using the high bandwidth and data transmission rate of Ka-band and the new-generation high throughput satellite (HTS) Ku-band satellite systems. These have downlink rates to the aircraft of 30Mbps or more.

These systems have allowed airlines to provide free internet access, resulting in take-up rates of more than 90%.

Connectivity options

Data downlink rates are generally increasing. The systems available to airlines, however, vary depending on the area of operation. The US and Canada have some of the simplest and highest data rate solutions for airlines.

US air-to-ground

Gogo's air-to-ground (ATG) system operates on transmissions from 200 land towers, and has a 300MHz bandwidth available for transmissions. The original ATG1 has a peak transmission rate of 2-3Mbps, and allows e-mails, text messages and simple internet browsing. Gogo's ATG is a paid-for service used in North America.

The increased use of ATG1 led to the launch of ATG4 in 2012, which has a higher transmission rate of 10Mbps. It is a paid-for service for internet browsing, and can also be used to provide a small number of live TV channels. ATG is also exclusive to North America.

SwiftBroadband (SBB)

Inmarsat's SwiftBroadband (SBB) was one of the first Satcom systems used for external cabin connectivity. It is based on L-band technology, and has a downlink rate to the aircraft of about 480 kilo bits per second (Kbps). This is high enough to allow the simpler cabin services of e-mail, text messaging, voice calls, and low-level internet surfing.

Ku-band

The first generation Ku-band satellites are operated over regional areas by several satellite operators. These were originally developed for domestic TV transmissions, so they have a wide beam configuration. All appliances and aircraft using the same encryption code can gain access to the transmission, so the transmission rate to each aircraft is low. When adapted for commercial aircraft, the first satellites had transmission rates of 1-2Mbps, while later ones have up to 10Mbps.

In response to the launch of Ka-band satellites over the past decade, Ku-band satellite operators are launching high throughput satellites (HTS) and extra HTS (EX HTS) satellites. These will use the same spotbeam configurations as Ka-band satellites to concentrate the beams' power in a smaller area, which will be shared by a smaller number of aircraft. The downlink rate each aircraft receives will therefore be relatively high, in the region of 30Mbps.

Gogo has become a Ku-band connectivity provider, and has launched a global service called 2Ku-band. This will provide high downlink rates of up to 70Mbps, because the aircraft will have a two-phased array antenna. 2Ku-band should allow all levels of service on board the aircraft, including the live streaming of movies and live TV.

Gogo's 2Ku-band service will initially be the only external connectivity system that can be used with the company's new live internet protocol TV (I.P.TV) service called Gogo TV.

Ka-band

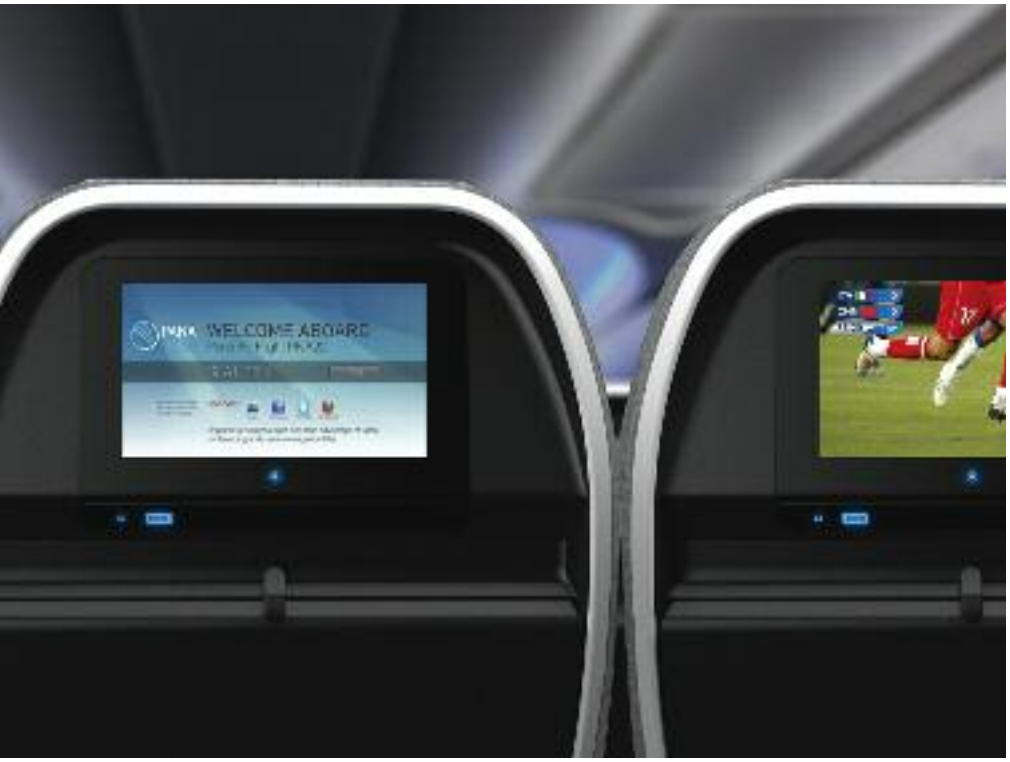
Ka-band satellites are configured with spotbeams. As described, concentrating transmission over a relatively small area increases the downlink rate to each aircraft. This is enhanced by the fact that the same frequencies can be re-used in non-adjacent spotbeams, thereby increasing the satellite's total capacity.

Ka-band satellites are available in a few regions, but there is also a global service. ViaSat provides Ka-band coverage primarily over North America, but also over a few adjacent areas, such as the Caribbean and the North Atlantic. ViaSat's satellites were originally configured for two-way communications to provide domestic internet services in the US. They have since been adapted for use in commercial aviation.

ViaSat's first two satellites have relatively low total capacities of nine gigabits per second (Gbps), but the later ViaSat-1 and ViaSat-2 satellites have capacities of 140Gbps and 280Gbps.

Similarly, European operator Eutelsat operates a Ka-band satellite over Europe called KaSAT. This has 80 spotbeams and has a total capacity of 90Gbps.

Inmarsat provides a global Ka-band service called Global Express (GX), with four satellites in orbit above the Equator. Each satellite has more than 80 beams, and a total capacity of 4-5Gbps.



Providing live TV is influenced by the configuration of the IFE and cabin connectivity systems, and the source of the TV transmission. Several airlines in the US are combining broadcast TV transmitted from Ku-band satellites established for domestic TV with hardwired seatback screens.

Inmarsat was the first connectivity provider to offer airlines service level agreements (SLA), and offers up to 12Mbps to the aircraft with GX. ViaSat offers SLAs with an average of 10Mbps per seat 50% of the time, and an average of 3Mbps per seat 90% of the time.

EAN

There are fewer trans-continental services available for cabin connectivity in Europe than in North America. Inmarsat has recently launched its European Aviation Network (EAN), however.

The EAN consists of mainly an S-band external connectivity service, supplemented by Ka-band. This is mainly provided by ATG transmissions from 350-400 aviation-specific towers operated by Deutsche Telekom across the 28 states of the European Union (EU). These each provide signals out to an 80 kilometre (Km) radius, and so provide a cellular network across Europe.

This ATG cellular network is supplemented by S-band satcom called Europasat, operated by Inmarsat. This is used to fill in areas not fully reached by the ATG towers. Europasat also covers a larger area than the ATG towers, providing coverage at the extremes of Europe, such as the Canary Islands and Scandinavia. Together, these S-band satcom and ATG transmissions provide connectivity across 90% of Europe.

The S-band connectivity is further supplemented by Inmarsat's GX Ka-band service. Inmarsat controls the EAN network, which is now being offered to airlines. It will be operational from 2016.

"EAN is much better than GX for several reasons," says David Coiley, vice president of aviation at Inmarsat. "First, the equipment on the aircraft is small, comprising two small antennae that are each the size of a cup. All the equipment on the aircraft is about 20% of the weight of a satcom system. The main advantage of the ATG cellular network is that it provides high data capacity, because the cellular transmissions from non-adjacent ATG towers can be re-used as an aircraft flies through one cellular area to another. This is similar to the configuration of Ka-band satcom. The capacity of the EAN system is two times 15Mhz, and so several times more than Gogo's ATG.

"The EAN ATG cells are 160Km in diameter, so they are smaller than the spotbeams of Ka-band satellites," adds Coiley. "Each cell is split into three sectors, each of which has a transmission rate of 75Mbps. The sector's small size means there should be a relatively small number of aircraft flying through it, thereby providing a high downlink rate to each aircraft. In the case of busy traffic areas, there will be cells with smaller diameters and split into six sectors. This should maintain high data transmission rates to aircraft in busy areas."

Coiley says the service provided by EAN in the aircraft cabin should be close to a 4G network experienced on the ground. EAN will make high-speed, broadband internet access possible on aircraft for the first time across all of Europe.

A new satcom system will be launched from 2018 by operator OneWeb. Unlike the relatively small number of high orbit Ku- and Ka-band satellites which are mainly positioned above the Equator, the OneWeb constellation of Ku-band satellites will start with about 700 units and increase to 1,200. These will be low earth orbit (LEO) satellites in an array of orbits around the world, giving 100% global coverage. The main strength of OneWeb's satellite constellation will be high data transmission rates, which are expected to be 150Mbps to each aircraft. The system is due to be operational in 2021.

On-board services

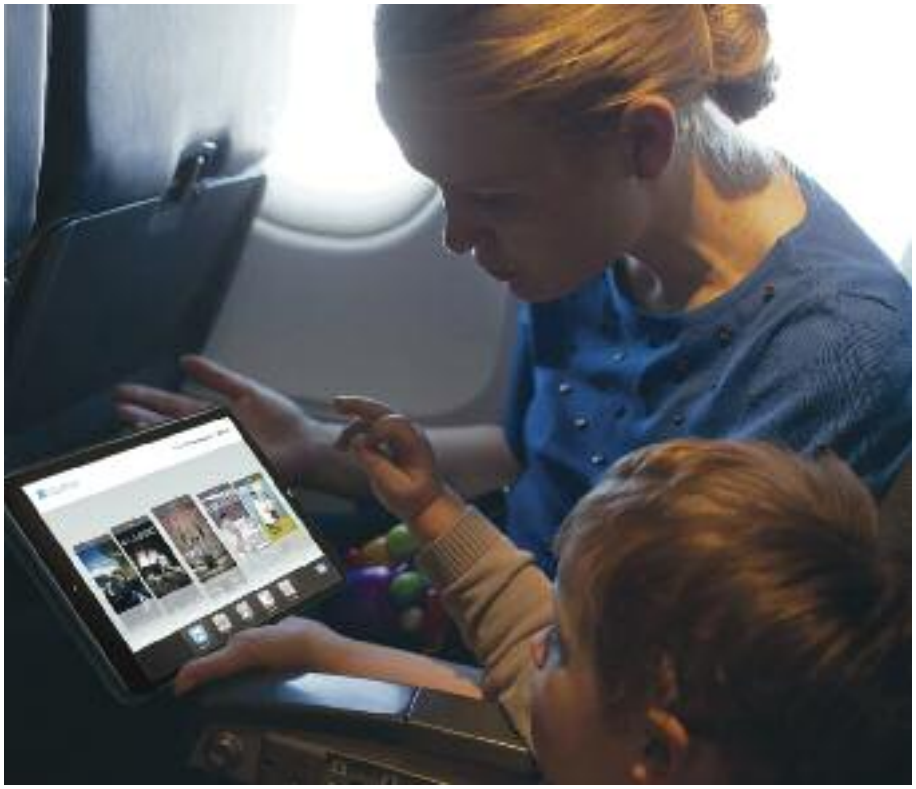
There are several reasons for demand for higher transmission rates and bandwidth. As described, the first is an increasing expectation from passengers for internet connection rates in the air that are similar to those on the ground.

The second main reason for demand for more bandwidth and higher data rates is a growing interest from airlines for live TV. This is relatively easy to provide in North America, but less so elsewhere.

Broadcast TV

US, Canadian and Brazilian airlines have used Ku-band satcom services already in place for domestic TV transmissions. Ku-band satellites were configured as wide beam transponders for sending one-way broadcast TV transmissions to a large number of houses. "The system was adopted for commercial aircraft, and each aircraft carrying the encryption code can access the same transmission," says Richard Nordstrom, marketing director of cabin systems at Rockwell Collins. "The quality of TV transmissions received by each aircraft, via Ku-band, is virtually the same, up to quite a large number of aircraft flying under the transponder beam. A typical direct broadcast satellite (DBS) may have 16 transponders, and each may support several TV channels. Each TV channel may need 2-12Mbps."

Ku-band has provided a relatively simple solution for airlines in North America and Brazil because only two or three languages are spoken by most of the passengers on board. Most passengers also share the same culture and nationality so a large number of TV channels can be supplied in the same language, and transmission to aircraft operating over the US, Canada and Brazil will be the same as transmission of TV



AviIT's BlueBox IFE system is based on airline-owned tablets that are pre-loaded with LW and EW movies, audio, games, and pre-programmed TV shows.

channels to domestic residences. It has therefore been relatively easy to adopt Ku-band for broadcast TV for airlines in North America and large countries. The same satellite operators that provide transmissions for domestic purposes can also be used by airlines. This includes DISH TV and Direct TV in the US, Bell Express View in Canada, and Sky Brazil in Brazil.

The US airlines that use Ku-band for live TV can provide a relatively large number of TV channels, and some do not have to pre-load TV programmes to on-board IFE servers. Some airlines with this configuration then use a separate Ka-band satcom channel for internet access.

There are a few airlines that utilise Ku-band for providing live TV on long-haul flights. This includes Lufthansa.

"The ability to offer live TV is influenced by the configuration of the IFE and connectivity systems, and the source of the TV transmission," says Anna Schiller, manager of content, connectivity and IFE at jetBlue. "The external connectivity used and configuration of the hardware and antenna both have an impact. IFE systems will either be embedded or wireless. At jetBlue, we use an embedded IFE system, Ku-band and source live TV from Direct TV. Direct TV only works with a hardwired connection, whereas Ku-band can be used for both broadcast TV and IPTV. IPTV requires a higher data downlink rate, and so needs a different IFE system architecture."

The issue with Ku-band broadcast TV is that it is not IP-delivered to the aircraft, so it does not broadcast directly in the cabin to PEDs on a wireless basis. "You therefore typically see broadcast TV delivered via an overhead or hardwired seatback screen," says Nordstrom. "Broadcast and seatscreen systems are hardwired, so they have a lot of capacity to distribute." This makes it possible to offer a large number of live TV channels.

IPTV

An example of Ku-band being used for IPTV is Southwest Airlines. The transmission is delivered wirelessly to PEDs in this system configuration. Southwest also uses the Ku-band connection to provide internet access.

IPTV is clearly delivered to the aircraft in I.P. format, and PEDs are designed to handle IP packets. IPTV can therefore work with a wireless IFE system, and either a Ku- or a Ka-band external satcom system. "If the IP delivery of TV is captured by the aircraft, the number of TV programmes that is possible is all dependent on the IP stream size or downlink rate, as well as the capacity of the cabin wireless access point and server system," explains Nordstrom.

Gogo's 2Ku-band service will be used together with its new IPTV service, Gogo TV. Gogo TV will provide live IPTV to passengers' PEDs via cabin WiFi. The service will initially only be available together with its 2Ku-band product. It will be launched in 2016 with Brazilian airline GOL.

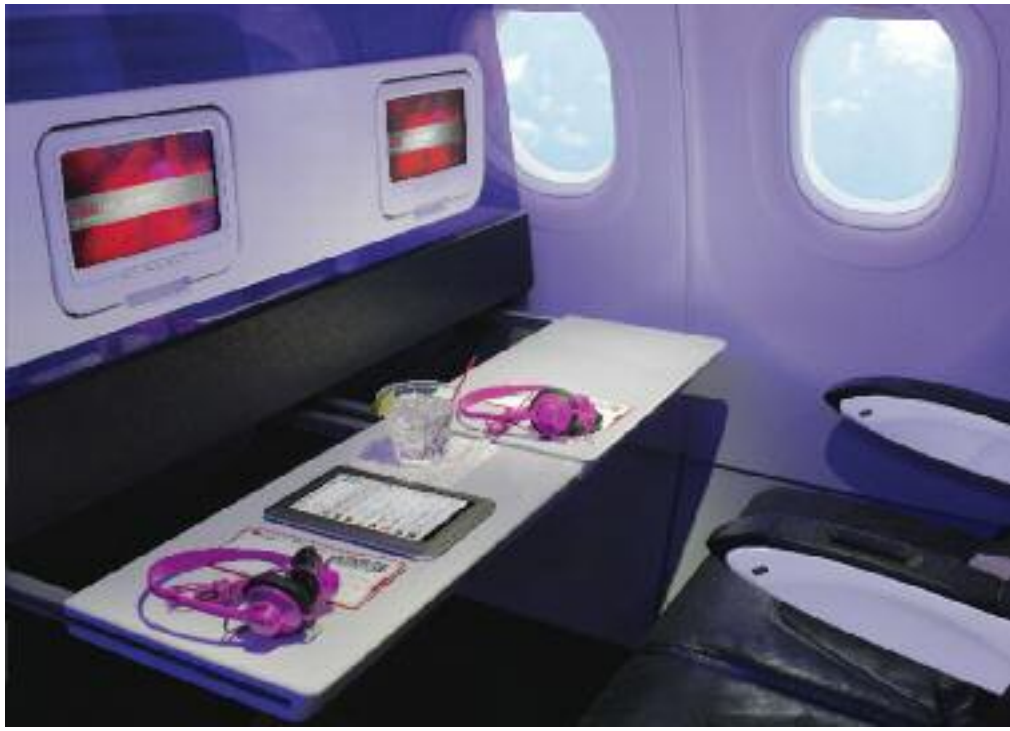
The live TV programmes available will be sourced through the internet, rather than via broadcast TV. Gogo will provide Bloomberg and One World Sports for demonstration purposes. Gogo says it will then work with airlines to determine what channels they will require. WestJet has three live IPTV channels on its new IFE system. These are BBC, CNN and CNBC.

Supplying live TV to airlines in Europe is different from doing it in the US. Unlike the US, the first main problem of supplying live TV to aircraft is that there are more than 20 languages and an equal number of cultures in the region. To satisfy demand for live TV on a European-wide route network, a short-haul fleet would need to be equipped to provide a larger number of TV channels than US carriers. "Typical passenger mixes on intra-European flights mean that six nationalities may be carried on most flights, so several dozen and up to 70 live TV channels would have to be available to satisfy all demand," claims Coiley. "The implication of this is that IPTV is the only way of technically delivering several channels for multiple languages and cultures.

"The other main issue affecting the supply of live TV on board flights is that current licensing laws mean it is not possible to receive a country's domestic TV outside of its own borders, unless an additional licence fee is paid. This makes it expensive to view a particular country's TV over the whole of Europe," continues Coiley. "A French passenger, for example, is unable to access broadcast French TV channels when flying over most of Europe. IPTV is therefore the only way to have multi-country TV channels on a flight because IPTV targets the individual aircraft, and it streams the TV channels from the ground sources through an internet connection. This is expensive, however, when most flights are 90-120 minutes in length."

Coiley expects that TV is most likely to be provided on European flights by passengers streaming their own TV choices via internet links. This is different to airlines selecting some of the same channels that are broadcast on the ground, as is the case in the US.

IPTV can be transmitted via Ku-band, Ka-band, or EAN. A high bandwidth and transmission rate will be needed, however, to satisfy the potential demand. Coiley predicts that EAN, with its high transmission rates, will force the TV licensing laws to change and relax. This may make it feasible to use broadcast TV in the future.



Virgin America will introduce its higher-specification Beta Red IFE system. This is an embedded system coupled with Ku- and Ka-band external connectivity. The Ku-band will provide 18 live TV channels via DISH TV. The interactive system provides games, audio and visual content. Ka-band will provide broadband cabin connectivity for PEDs.

The launch of Gogo's TV service for receiving IPTV, combined with its 2Ku-band product, may make on-board live TV more likely in parts of the world where there is less complex licensing and fewer languages than in Europe; and simpler and closer to the situation in the US, Canada and Brazil.

Lufthansa offers live TV on its long-haul fleet. The channels are Sport24, CNN and Euronews. These are accessed either through PEDs or the seatback screens, and are available free of charge.

Airlines

An airline's choice of IFE systems will often reflect the type of airline and the market it is operating in. Charter and low-cost airlines generally opt for the cheapest and simplest systems, especially standalone, pre-loaded systems that require no external connectivity.

The highest specification IFE systems are those operated in the premium cabins of full-service, long-haul operations.

Hawaiian Airlines

Hawaiian Airlines operates a fleet of turboprops, narrowbodies and widebodies on local flights in Hawaii and close islands, and a small number of long-haul services. It operates A330-200s and 767-300ERs on long-haul routes.

Hawaiian has opted for a pre-loaded, standalone IFE system, AviIT's BlueBox, on its fleet of eight 767-300ERs. The aircraft are operated on flights of up to eight hours to: the US; Sapporo, Japan; and Pago Pago, Samoa in the Pacific.

The BlueBox standalone IFEsystem is based on iPad minis, which are pre-loaded with content, including EW and LW movies, pre-programmed TV shows, and games. The content is refreshed every two months.

Derek Miw, manager of IFE at Hawaiian Airlines, explains that the iPad minis are relatively small, with 64GB of capacity. This compares to at least 1TB of hard disk space on the servers of seatback systems.

Hawaiian Airlines does not yet have plans to provide in-cabin WiFi, although Miw says the airline realises the demand from passengers for external connectivity.

The other main hardware the system needs is charging carts for the iPad minis. These are supplied by Ergotron, and each one charges 48 iPad minis. Charging ports could be installed in the seats, but the 767-300ER fleet is due to be phased out. Miw says that Hawaiian plans to expand the use of portable IFE devices, so it could include them in the interior enhancements to its A330-200 fleet, or on its forthcoming A321neo fleet.

Virgin America

Virgin America is a small US airline that started operations in 2007. It operates from hubs at Los Angeles and San Francisco to a small number of mainly major eastern US cities, and has a fleet of 56 A320s. It also operates to Hawaii and to three Mexican cities.

Virgin America operates as a low-cost and low fare airline, while providing a high level of cabin service. It was the first US airline to offer Gogo's in-cabin WiFi service on every flight. This was with Gogo's original ATG service, and was upgraded to ATG4 from December 2014. ATG4 has downlink rates of up to 10Mbps compared to 3Mbps with ATG.

Virgin America's IFE system is its Red, embedded and interactive system which is installed on 53 A320s. This includes Gogo's ATG4 that provides a paid-for internet access service, which can be accessed via in-cabin WiFi. The interactive IFE system provides on-demand entertainment. This includes live TV, pre-loaded TV programmes, games, and audio content and movies. The system also allows passengers to order drinks and snacks during flights.

The airline recently announced that it will be upgrading Red to Beta Red, which will first be installed on 10 A320s that it will take delivery of. This is also an interactive system, but the aircraft will be equipped with dual Ku- and Ka-band satcom connectivity provided by Viasat. Virgin America's fleet will be equipped with a new hybrid Ku-/Ka-band antenna.

The Ka-band system will be used to provide high-speed, broadband internet access while operating over the US mainland and in range of Ka-band reception. This is possible because the ViaSat-1 satellite provides 140Gbps of total capacity. ViaSat estimates this can deliver data rates to each seat of 12-20Mbps.

This will be trialled as a free service from September 2015 to March 2016.

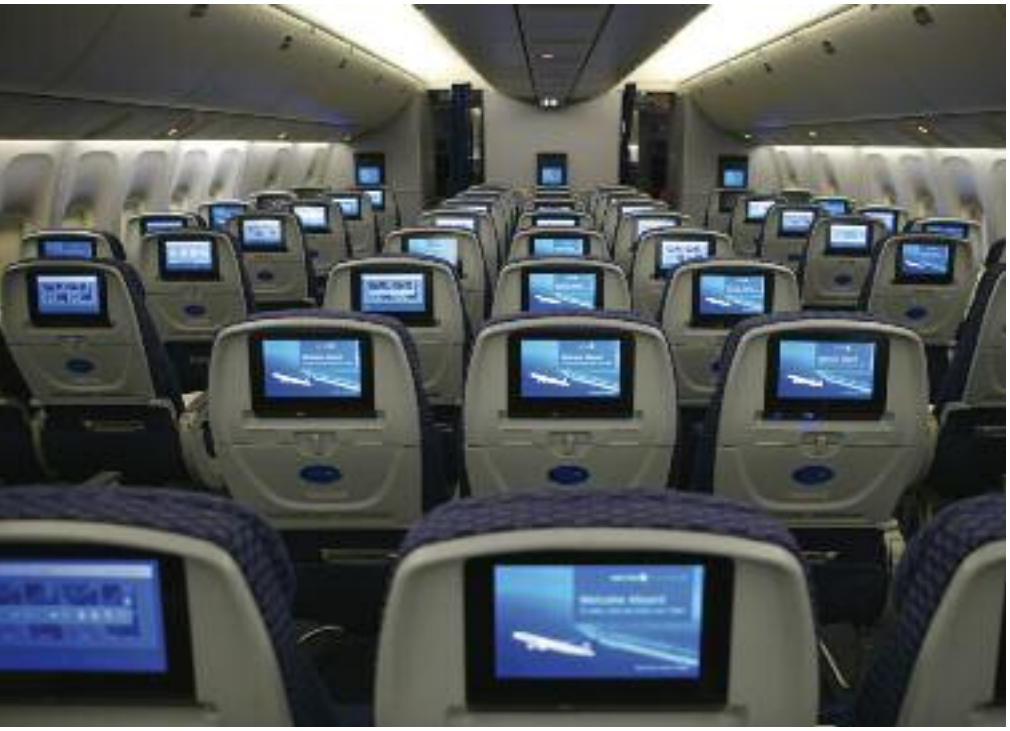
The Ku-band will be used to provide internet access on international and over-water flights when operating outside of Ka-band coverage, so it will mainly be used between the US West Coast and Hawaii.

The Ku-band system also allows Virgin America to provide 18 live TV channels to the aircraft's Beta Red hardwired seatback IFE system. The Ku-band is operated by DISH TV and sourced through ViaSat, and provides the 18 live broadcast TV channels.

The enhanced Beta Red IFE system will also provide games, audio and visual content through the seatback screens.

Westjet

Canadian carrier Westjet is a large low-cost carrier (LCC) with a large Canadian domestic route network. It also serves a large number of US and Caribbean cities mainly with its 737NG fleet. It also operates a small number of long-haul routes to the UK with 767-300ERs. WestJet's fleet includes 115 737NGs an four 767-300ERs.



United Airlines has an embedded IFE system on its long-haul fleet. This provides movies, pre-programmed TV shows, audio, and gaming content. United also equips its long-haul fleet with Ku-band to provide internet access via PEDs. Its short-haul fleet is fitted with both Ku-band and Ka-band. The Ku-band is to provide live TV channels from Direct TV, while Ka-band allows high-speed internet access on US domestic flights.

Westjet's new IFE system is Westjet Connect, provided by Panasonic. This is combined with in-cabin WiFi connectivity for use with PEDs, which is Panasonic's eXConnect system. It was launched in July 2015, and is being installed on all of WestJet's jet aircraft.

The precursor to this system is live TV via seatback screens, providing 24 live TV channels and four channels of movies. It is available through a satcom connection provided by Bell TV.

The seatback screens will continue to be used while the new system is installed, but will be removed once installation is complete at the end of 2016.

Passengers have to download an app onto their devices prior to boarding when using the new WestJet Connect system. The app takes passengers to the WestJet Connect homepage, from where they can access the content and internet.

The new IFE system includes Ku-band external connectivity, also provided by Panasonic. WiFi connection is paid for by passengers at a rate of $8-9 per flight. As well as accessing the WestJet Connect homepage and the system's content, they can also use PEDs to send/receive e-mails and surf the internet.

Content available to passengers includes new and EW and LW movies, three live TV channels, pre-loaded TV, and audio and games. All content on WestJet Connect is free.

At the launch of WestJet Connect there will be 85 movies and 329 pre-loaded TV programmes, equal to more than 450 hours of visual content. The content will be refreshed on a monthly basis.

The three live TV channels will be BBC, CNN and CNBC. They will be accessed via passengers' PEDs via the cabin WiFi connection. The TV channels will thus be IPTV, and will be eXTV by Panasonic's broadcast satellite. This is the same satellite that provides WestJet's cabin connectivity and internet service.

The airline also provides 110 volt AC and 5 volt DC USB power plugs in the seats of its 737NG and 767-300ER fleet.

Although the system relies on PEDs, WestJet also has a limited number of tablets to rent on flights longer than three hours for a price of $7-8. These are pre-loaded with movies and TV shows, and so cannot be connected to the internet.

The longer routes on the network serving the US and international destinations either have seatback screens or provide tablets to rent. These flights have free stored content programming.

jetBlue

jetBlue started operations in 2000, operating as an LCC with full cabin service and TV on board. It now operates a fleet of 213 A320/321s and E-190s, and is the fifth largest US airline. Its route network is over North America only.

jetBlue's hybrid IFE system combines embedded seatback screens and provides free WiFi for internet access for use with PEDs. "The seatback screens provide a large number of free live TV channels. The A320 and E-190 fleets have 36 live TV channels, while the more recently added A321 fleet has 100-plus live TV channels," explains Anna Schiller, manager of content, connectivity and IFE at jetBlue.

The airline also includes 100 Sirius XM satellite radio channels as part of its IFE offering, via its satcom links.

jetBlue is one of several North American carriers that has a dual external satcom system. This is both Ku- and Ka-band. "The Ku-band was installed on our fleet from 2009 to provide live TV," says Schiller. "The satcom connection is provided by US TV satcom company Direct TV and sourced through Thales. We offer broadcast TV, rather than IPTV. The configuration of a hardwired, embedded IFE system, together with the antenna and use of broadcast TV means that we can provide a large number of live TV channels. Broadcast TV needs a relatively low data rate, and Direct TV can only be used with a hardwired IFE system."

Ka-band started to be installed on jetBlue's fleet from 2009, and is used for the airline's free in-cabin WiFi product Fly-Fi. This is used by passengers to access the internet through their PEDs. "The Ka-band is provided by US operator ViaSat, which operates its own satellites," explains Schiller. ViaSat's exede product includes several satellites that provide connectivity over North America with downlink rates as high as 140Gbps. The take-up rate of this service is about 40%.

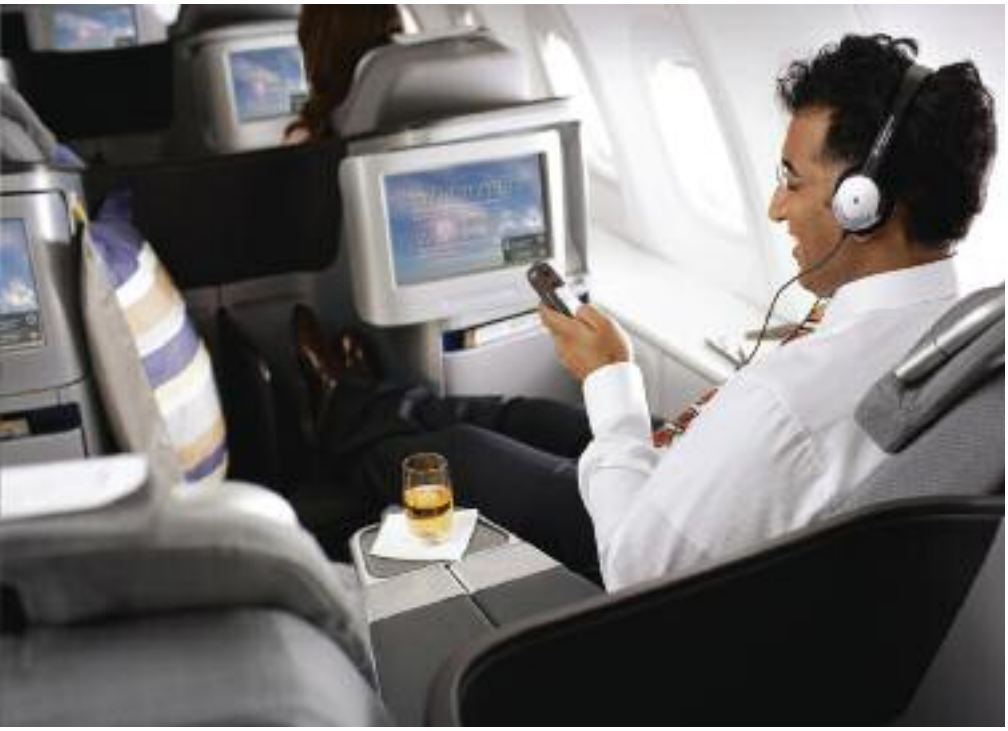
The Ka-band antennae and system were added to the aircraft that already had the Ku-band system fitted from 2013. The A320 and A321 fleets have all been fitted with Ka-band, while the first few aircraft in the E-190 fleet have now had the system installed.

Additional content in the IFE system includes free EW movies on flights that operate outside the area of Direct TV reception, and for passengers in premium classes. Economy-class passengers have to pay $5 per movie when in the area of Direct TV reception.

jetBlue also has in-seat chargers for PEDs.

United Airlines

Following the absorption of Continental, United Airlines has become the third largest airline in the US. The mainline carrier operates a fleet of 720 aircraft, and has an extensive domestic US and international long-haul network. It operates a fleet comprising mainly of A320 family and 737 family types on its domestic network; and a fleet of 757-200s, 767-300ER/-400ERs, 787s, 777-200s and 747-400s on its long-haul network.



Lufthansa has a comprehensive embedded and BYOD IFE system on its long-haul fleet. This includes Ku-band provided by Panasonic, and its used to provide live TV and in-cabin WiFi for internet access. The system also features the FlyNet portal. This includes updated news, flight information, and shopping.

United uses an embedded system on its long-haul and international fleet, while utilising a BYOD/PED wireless system on its short-haul fleet.

It is one of several North American airlines using Ku- and Ka-band external connectivity satcom services, to provide in-cabin internet access and live TV.

The Ku-band is provided by Panasonic, while Thales provides Ka-band using the high-capacity ViaSat satellites that broadcast over North America.

United uses Ku-band primarily on its international fleet and a few select aircraft in the short-haul fleet. These were fitted with external satcom connectivity prior to most of the short-haul fleet being fitted with Ka-band.

A live TV service is delivered separately through a Ku-band antenna on domestic aircraft, which are also fitted with Ka-band connectivity. The Ku-band system provides broadcast live TV from the Direct TV satellite system.

WiFi access is a paid-for product, and the live TV is paid for in economy class on domestic flights. United provides more than 100 live TV channels, and eight pre-recorded ones with films and TV shows.

United also offers on-demand entertainment through its embedded IFE system on its international and long-haul fleet. This includes 150 movies, 185 TV shows and a large choice of audio and gaming content. In addition, United streams free visual and audio content to PEDs, via the cabin wireless system.

Oman Air

Oman Air operates from its hub at Muscat with a fleet of ATR-42s, E-175s, 737NGs, 787s and A330-200s/-300s. The airline is in the process of updating its IFE and external connectivity system.

Oman Air currently uses Inmarsat's swift broadband (SBB) satcom system for external connectivity for its widebodies, and also has a traditional seatback IFE system installed on all jet types.

"We want to install Ka-band on our fleet, but we are waiting for line fit from the aircraft manufacturers," says Dawood Al Raisi, senior manager technical projects at Oman Air Engineering & Maintenance. "We are also working to define the configuration of our new single-aisle aircraft, and big decisions will have to be made about using a wireless IFE system and cabin wireless connectivity.

"All the IFE hardware for the embedded seatback system is supplied by Thales, and are the i4500, i5000 and AVATN systems," says Al Raisi. "These provide AVOD, an interactive map, and advertising."

Oman Air currently charges for use of internet access in the cabin with its SBB system. Al Raisi says that the airline is looking into providing it for free in premium classes. Although Oman Air does not see much need for streaming live content, Al Raisi says one exception is for sports events. Once a higher connectivity bandwidth can be provided to passengers, they should be able to stream whatever they want to their PEDs.

Lufthansa

Like United, Lufthansa operates a varied fleet of international and short-haul types. Lufthansa operates a mixture of A380s, 747-400s, A340s and A330-300s on an extensive international network; and a fleet of mainly A320 family aircraft on its European routes.

The airline has had a comprehensive IFE system on its long-haul network for several years. This includes the use of Ku-band satcom for external connectivity, provided by Panasonic. This is used to provide live TV and a paid-for WiFi and internet access service on board long-haul flights, which the airline has been offering since 2003. Lufthansa charges 14 Euros for flights longer than four hours, and 17 Euros for the longest flights or combined flights of up to 24 hours. Despite charging for the service, Lufthansa says its paid-for internet users have tripled over the past few months.

Lufthansa says the Ku-band system provides data downlink rates of 40Mbps. It will later be upgraded to Ku-band HTS system, after the HTS satellites are fully operational. Panasonic will then upgrade the Ku-band external connectivity service it offers. This system will provide much higher data downlink rates. Panasonic will also be using extreme HTS satellites (EX HTS). A hardware and software upgrade will be required on the aircraft.

The on-board IFE system is a combination of a traditional embedded system and a BYOD/PED system; which can use the on-board WiFi network.

The free content provided includes a comprehensive FlyNet portal. This has been available on all of Lufthansa's 106 long-haul aircraft since the start of 2015. This includes regularly updated news, flight information, destination-based information, shopping, live TV, and e-publications.

Lufthansa also provides a mobile calling service from AeroMobile for voice calls and text messaging. It allows PEDs to be used on the airline's long-haul fleet.

Lufthansa is the first airline to sign up to EAN, which will become available in 2016. Prior to this, Lufthansa will start offering cabin connectivity from summer 2016 with Inmarsat's GX system. Lufthansa is expecting data downlink rates of at least 15Mbps to each personal device.

Lufthansa's IFE system on its short-haul fleet will be wireless. It will charge nine Euros for access on flights up to one hour, and 14 Euros on flights up to four hours. AC