The rapid development of external connectivity and satellite systems is allowing airlines to move away from the limitations of traditional embedded IFE systems. Airlines can now offer a wide range of passenger entertainment systems, and generate new revenue streams.

Cabin connectivity & revenue-generating systems

The past few years have seen a steady evolution in the number and variety of passenger cabin entertainment systems. These systems can have both live or streamed, and server-based content. This development has increased the scope for airlines to generate revenue from cabin and in-flight entertainment (IFE).

An improved variety of cabin and IFE systems and a greater potential to generate revenue is due to the development of more external cabin connectivity systems, and the supply of internal cabin signals that make possible a live connection between the passenger seat and the ground. The various cabin connectivity, cabin service and IFE, and revenue-generating systems available on the market are examined here.

Cabin system components

Modern and current generation cabin entertainment and IFE systems include: the use of phone calls and text messaging; internet access and e-mail capability; live TV; live or streamed audio, visual and magazine content; content from servers on the aircraft; and shopping with real-time credit card transactions.

The three main systems that make current generation cabin entertainment possible are: external cabin connectivity; internal cabin connectivity; and cabin service and IFE hardware.

There are several permutations of cabin service, internal signal, and external connectivity system that an airline can consider when configuring its aircraft.

An airline's choice will ultimately be determined by the type of service it operates, what it wants to offer its passengers on a complimentary basis and what it wants to charge for, what it can charge for a service, the likely acceptance and uptake by passengers, and the costs of providing the service.

The two types of external connectivity system are: Gogo's cellular air-to-ground (ATG) system, which is used exclusively in North America; and satcom. There are several types of satcom services, and these are due to be expanded over the next few years. Each satcom service has its own data transmission rate to the aircraft, and these rates are generally increasing as new systems are introduced.

Internal cabin connectivity systems and signals are either global system for mobile communications (GSM) cellular signals, or WiFi signals. The use of cellular signals is not permitted in aircraft cabins when operating over US airspace, however. In this case, aircraft are limited to using only WiFi signals. GSM signals have limited applications.

External connectivity

There is now a large number of external connectivity systems for airlines to choose from. These systems fall into two categories: cellular ATG signals and satcom communications. ATG communications only exist in North America, and to a limited extent in Europe. There are several providers of satcom services. Only some of these provide global coverage for aircraft and shipping, however, while others only provide regional services.

The data transmission rate of external satcom connectivity systems is the first main factor that determines what is possible in the cabin. The transmission rate down to the aircraft (downlink) is nine to 10 times higher than the transmission rate up to the aircraft (uplink) in cabin services and IFE. This is because a larger volume of data is downloaded to the aircraft than is transmitted up from it during cabin services and passenger entertainment.

The on-board services that use and require the lowest data transmission rates are e-mail and text messaging. Phone calls require a data transmission rate of 1-2Mbps, which is not much more than e-mail and text messaging.

Internet browsing requires higher data downlink rates, but transmissions are only required when pages are being downloaded by passengers. No data transmission occurs when pages are being read. A higher external connectivity downlink rate will provide a superior browsing service to a larger number of passengers.

Internet access not only means that passengers can view websites, but also allows real-time credit card transactions to be made by cabin crew. Steve Nolan, director at Gogo, estimates that a downlink rate of at least 3 Mbps is required for basic internet access.

The four main services of e-mail, text messaging, phone calls, and internet browsing with live credit card transactions all require relatively low data downlink rates of up to 3Mbps.

Live television is possible for those aircraft equipped with higher external and internal data transmission rates. "One stream per TV channel is required for the whole aircraft, regardless of the number of passengers watching," says Norbert Mueller, senior vice president of BroadConnect at Lufthansa Systems. "Each stream or channel requires a downlink rate of about 1Mbps. An airline that offers 10 live TV channels therefore needs an external connectivity system with a downlink rate of about 10Mbps, as well as additional downlink capacity to provide the other services."

The next level of cabin service is the provision of music or audio, magazine pages, and video or movies. These can be provided from an aircraft server, or streamed live from a source on the ground.

Audio and visual content that is streamed live from the ground requires a higher data transmission rate than live TV. "In the case of streamed movies and video on demand, the aircraft needs one

With the advent of cabin satcom systems with high data transmission rates, airlines now have the option of removing embedded IFE systems, or offering them in combination with cabin WiFi signals that passengers can use to access IFE servers with their own electronic devices.

channel and 1Mbps per passenger," says Mueller. "This means that a downlink rate of 50Mbps would be needed if 50 passengers on the aircraft wanted to watch streamed movies. Additional data transmission capacity would be required for the other services. Streamed audio only needs about one-tenth of the data transmission rate of streamed movies, which require the highest data downlink rates of all in-cabin services."

Nolan estimates that a higher downlink rate of about 70Mbps would actually be required for video on demand, or streamed visual content and movies.

The alternative to streaming audio and video or film content is providing it from an IFE server on board the aircraft. The content is uploaded to the IFE server when the aircraft is on the ground, usually using on-the-ground fourth generation (4G) GSM or WiFi facilities. The external in-flight connectivity downlink rate therefore is not relevant.

ATG & satcom

Airlines have an increasing choice of external connectivity systems. The main issues are geographical availability and downlink transmission rates.

Gogo ATG

Gogo is the exclusive provider of ATG cellular connectivity in North America. Gogo provides this together with internal cabin WiFi signals to airlines, with cellular transmissions not permitted inside aircraft cabins when flying in US airspace.

Gogo has a licence for a 3Mhz bandwidth of ATG communications, and it has built more than 200 transmitters in the US, Alaska and Canada to provide complete coverage across North America. The original version of ATG has a peak data transmission rate of about 3Mbps to the aircraft. This is high enough for passengers to have general internet-browsing capability.

There are nine airlines in North America that use this system, and more than 1,500 of their aircraft are equipped with it.

Gogo launched a second generation system in 2012, known as ATG4. This has a higher peak data transmission rate of about 10Mbps. This allows a more consistent internet-browsing experience for a high percentage of passengers on board an aircraft. Four airlines use ATG4, and more than 550 aircraft are equipped with it.

One GoGo US customer is Delta Airlines, which uses the ATG system for its domestic and regional fleet.

Outside of US and North American airspace the only external connectivity option for airlines, with the exception of parts of Europe, is satcom. Airlines should be careful to distinguish between satcom systems that provide global coverage, and those that are only available on a regional basis. Some satellite systems, such as Inmarsat, have been specifically developed for moving users, such as aircraft and ships, and have global coverage.

Other satcom systems were originally developed for different purposes, including stationary users or cars, and have been developed for a specific region, such as Europe and the Mediterranean. They have since been adapted for aviation, but still only provide regional coverage. One example is Eutelsat which provides coverage in Europe.

L-band & swiftbroadband

Several satcom systems based on L-band are offered by Inmarsat and Iridium for flightdeck transmissions. These have relatively low downlink rates to the aircraft. They can be used for some cabin services, but are limited to e-mail and text messaging.

Inmarsat's SwiftBroadband (SB) has a downline rate of up to 480Kbps. This has been in use for cabin-related connectivity on aircraft for about five years. The transmission rate is high enough to allow e-mail and text messaging, as in the case of L-band satcom, as well as voice calls and low-level internet browsing.

"Inmarsat SBB provides enough bandwidth for e-mails, text messaging, and basic browsing of static websites," says Duc Huy Tran, director of cabin systems at Rockwell Collins. "For this level of capability, Inmarsat SBB provides the best combination of speed and price."

Ku- & Ka-band

The two main types of satcom used up to now for cabin connectivity and in-flight services are Ku- and Ka-band. Ku-band has lower data transmission rates than Ka-band.

Ku-band is provided by several suppliers that include Rockwell Collins, Panasonic, Global Eagle Entertainment (GEE), which acquired Row44, and several others.

Standard Ku-band has a downlink rate down to the aircraft of about 10Mbps. This is sufficient for the basic services of e-mail, text messaging, and voice calls. It also allows high-speed internet access and also the streaming of a small number of live TV channels to the aircraft.

There are several versions of Ku-band, and each provider has different levels of service. "We offer a downlink rate of up to 10Mbps," says Jags Burhm, vice president of sales at GEE. "The transmission rate up from the aircraft is about 1Mbps. The downlink rate is the most important for the services that are possible on-board. This is sufficient for 50-70 passengers to have web browsing, e-mail, and up to 15 channels of internet protocol (IP) live TV. Southwest, for example, provides 15 TV channels with our system on 450 of its aircraft. We have

High data transmission rate satcom systems have increased the range of IFE services. These include live internet access and the streaming of live TV.

had up to 160 passengers on a Norwegian Airlines aircraft simultaneously using the system for free. The Ku-band system is therefore sufficient for most widebodies."

Gogo will also introduce an enhanced Ku-band service called 2Ku-band in 2015. This has a transmission rate of 70Mbps or more, and will provide a consistent service almost over all global regions. The system will be trialled by Air Canada, and Aeromexico has already committed to it.

2Ku-band is being introduced because of the problem with traditional Ku-band, which has to be powered down in tropical and equatorial regions so that it does not interfere with other satellites. 2Ku-band will resolve skew angle complexities. The system has a downlink rate that will allow all possible services, including live TV and the streaming of on-demand video content. It is optimal for I.P. TV.

2Ku-band uses the current Ku-band satellites, and will use spotbeam satellites in the future. The antennae on the aircraft are low-profile, with a height above the aircraft of only 17cm. The service will be available from mid-2015.

An even higher downlink rate of up to 100Mbps may be possible with the use of two antennae.

The original and regular Ka-band service has a downlink rate of about 10Mbps. This service allows the same services as standard Ku-band, although Ka-band's higher transmission rate allows a better internet browsing experience.

There are several Ka-band providers. Inmarsat provides a global coverage, built-for-purpose mobile satellite system, intended for moving users. Inmarsat does not sell directly to the airlines, but instead has several partners, or value-added resellers, which sell air time and the associated hardware to airlines, and also provide them with on-board solutions and related customer care services. These partners include Gogo, OnAir, Honeywell, Rockwell Collins and Thales.

Inmarsat's Ka-band service is its Global Xpress product. Honeywell signed an agreement with Inmarsat in 2012 to provide global in-flight connectivity services to airlines. Honeywell will exclusively develop and distribute the on-board hardware that will allow airlines to connect to Inmarsat's Global Xpress network.

"The 50Mbps downlink rate is the rate within each spotbeam transmission from the satellites," says David Coiley, vice president of aviation at Inmarsat. "The antennae on the aircraft are therefore capable of accepting a downlink rate of up to 50Mbps, although performance does vary throughout the day and with the number of aircraft flying under each spotbeam. There are antennae that could limit the downlink rate to much less than 50Mbps."

Inmarsat's Global Xpress allows all basic or standard services that can be provided by standard Ku- and Ka-band satcom, as well as live TV and streamed audio and visual content. Although Ka-band will allow the live streaming of movies and live TV, airlines will probably block this, since it will be more expensive than providing movies through an on-board IFE server.

Gogo will launch the marketing of Inmarsat's Ka-band service in 2015. "It will have a transmission rate down to the aircraft of 50Mbps," says Nolan. "This allows a better service for live TV and streaming of video from the ground."

Inmarsat S-band

In addition to Inmarsat's Global Xpress Ka-band product, Inmarsat has recently launched a new service called S-band for operations in the airspace of 28 European Union (EU) nations, over parts of the Mediterranean, and the North Sea, the Bay of Biscay, and the Baltic Sea. The EU has given Inmarsat access to a spectrum of frequencies provided by a new type of satcom, and a complementary terrestrial-based network across Europe. The terrestrial network in Europe is similar to that used by Gogo in North America.

Coiley says that S-band should give an average downlink data transmission rate of 70Mbps, but it will have bursts of up to 100Mbps. "The system is able to have multiple aircraft in the same area simultaneously achieving downlink rates of 70Mbps. The benefit of S-band is that it has a lot of bandwidth, and so can provide a high downlink rate service in areas of dense aircraft operations."

ViaSat

ViaSat is a provider of Ka-band services, and has three of its own Ka-band satellites over the US. ViaSat also has agreements with Eutelsat, which has similar satellites in Europe. "This means we can sell Ka-band coverage over the US and Europe," says Don Buchman, vice president of Exede Mobility at ViaSat. "In 2016 we will add a satellite over the Atlantic ocean to provide full transatlantic coverage. Our system provides a downlink rate of 1.2-1.5Gbps, equal to 1,200-1,500Mbps, from each satellite's beam. This high downlink rate avoids some of the problems that other satcom providers are experiencing with a large uptake by airlines and large numbers of aircraft flying under each satellite beam. It also allows us to promise a downlink rate of 12Mbps per passenger seat, regardless of how many people use the in-flight service."

Internal connectivity

Airlines have two means to provide cabin services and IFE: through an embedded IFE system; or wirelessly to passengers' personal electronic devices (PEDs), such as tablet computers and

Lufthansa Systems's BroadConnect system claims to have a data downlink rate of 300-500Mbps in the aircraft cabin. This is sufficient to allow the live streaming of TV and movies from the ground during flight.

smartphones.

Services, content and IFE provided through traditional embedded IFE systems, and the screens in the back of passenger seats, is via hard connections. Content that is streamed wirelessly to PEDs can be sent either using a GSM cellular cabin signal, or mainly via a WiFi cabin signal.

GSM signals are not permitted inside aircraft operating in US airspace, however. These aircraft are limited to using WiFi signals.

GSM signals in an aircraft cabin allow the use of e-mails, voice calls on mobile telephones, and more basic text messaging with short messaging service (SMS). Access to the internet on board an aircraft is technically possible with GSM on a smartphone, but is usually blocked by airlines because they want passengers to pay for internet access through WiFi signals.

WiFi signals in an aircraft cabin can be used to: send and receive e-mails; access the internet; make voice calls on mobile phones that have GSM over WiFi software installed; send text messages either using SMS or multimedia messaging service (MMS); and stream live TV or live audio and visual content.

With the correct combination of external connectivity, and GSM and WiFi signals in the aircraft cabin, passengers can use their PEDs to access all sorts of services.

Honeywell's in-flight surveys have revealed that in-flight WiFi availability is now influencing passengers' choice of airlines. Most airlines are considering offering WiFi access in the passenger cabin, or already offer it. Delta, for example, provides a paid for WiFi service in the cabin on all of its domestic US services. This allows passengers to: send and receive telephone calls, text messages, and e-mails; access the internet; and watch complimentary live TV.

The provision of GSM signals is less widespread among airlines.

Airlines have three main options for providing cabin services: to remain with traditional embedded IFE systems, although this will mean some cabin services like phone usage will not be possible; to provide only a WiFi signal for passengers to use with their PEDs; and to have a combination of a traditional embedded IFE system and WiFi signals for use with PEDs. In the last scenario passengers can access the internet and content such as movies and audio through the embedded IFE system, and perform all other types of services on their PEDs using on-board WiFi.

Provision of WiFi requires the installation of wireless access points (WAPs) in the aircraft cabin. The number of WAPs installed is generally proportional to the speed or quality of electronic services on PEDs.

One provider of cabin WiFi is GEE. "We provide two or three WAPs on a narrowbody aircraft, and so have 40-70 seats per WAP; and provide six to eight WAPs on a widebody," says Burhm. "We provide airlines with a turnkey solution, so offer Ku-band external connectivity together with WiFi internally in the cabin. This includes all the necessary hardware and the aircraft certification.

"We offer WiFi inside the aircraft cabin," continues Burhm. "The passenger only needs a software upgrade to use their GSM phone over the WiFi signal in the cabin while in-flight. The passenger downloads the conversion application onto their phone before boarding the flight, and then uses their phone for voice calls and text messaging while using the WiFi signal in the cabin."

OnAir is one provider of GSM signals in the aircraft cabin. "We provide a cellular network, as on the ground. The GSM frequency identification is done through the user's telephone's SIM card," explains Francois Rodriguez, strategy and marketing director at OnAir. "The user can then use the signal mainly for phone calls and SMS messaging. Some airlines also use the GSM network for credit card payment machines and live transactions.

"The passenger can roam in another phone network when on the aircraft, if the passenger's provider is one of the 250 global mobile providers that we have agreements with," continues Rodriguez.

"We also provide WiFi signals in the cabin. The basic service can be paid for by economy passengers, and is provided free to premium-class passengers," continues Rodriguez. "The uses are internet access, streaming content that is accessed via the IFE server on the aircraft, and streaming of time-sensitive and fresh content, such as news and sports."

Gogo is another provider of internal WiFi signals, and combines this with external connectivity products. "Providing internal WiFi signals requires an airborne central processing unit (ACPU), a modem, and a WAP," explains Nolan.

Lufthansa Systems' BroadConnect product provides an aircraft wireless platform. "This includes a server and a WAP in the passenger cabin to provide WiFi," says Mueller. "The system can then be used for off-line and on-line services. That is, streamed and server-based services. The system is configured to allow the airline to add in any external connectivity solution, and thus determine the downlink rate and bandwidth they require. We integrate our internal system with the external connectivity providers.

"We can provide a GSM signal with an appropriate partner, such as OnAir or Aeromobile," continues Mueller. "The main internal signal of our system is WiFi. What determines the service that can be provided is the number of parallel streams that are possible, and this partly depends on the number of WAPs installed in the cabin. The system's internal

capability depends on the WiFi traffic, and the server needs to be capable of handling certain transmission and data volumes. Our system allows total traffic in the cabin of 300-500Mbps."

Similar to other providers, Rockwell Collins provides a combination of cabin WiFi and Inmarsat SBB or Ka-band for external connectivity. It also provides the hardware for an embedded IFE system, and supplies this for the A320 and 737NG/737 MAX families. These systems are known as PAVES.

Cabin entertainment systems

As described, the two choices airlines have for delivering cabin entertainment are through an embedded IFE system, or to PEDs via a WiFi signal.

What can be delivered to the cabin is mainly determined by the external connectivity system and the downlink rate it provides. All possible cabin services can be provided via the seatback screens of an embedded IFE system, although many airlines like to offer WiFi signals as well, to give passengers the option of accessing services via PEDs.

Airlines looking for the cheapest alternative are removing their traditional IFE systems. They only provide WiFi signals in the cabin, and passengers need to use their own PEDs to access content from an IFE server on the aircraft.

Some airlines, however, are combining a WiFi service with free-to-use or hired PEDs, such as iPads, for the duration of a flight.

Airlines considering whether to provide an embedded IFE system or WiFi and tablet computers need to bear in mind the costs of acquisition, installation, and on-going support and maintenance. A wireless system, with just an IFE server, removes many of the components and so also reduces weight and thus fuel burn. A wireless cabin IFE system with just a server would not, however, allow live credit card transactions. It would also prevent passengers from sending and receiving e-mails, text messages, making phone calls, and accessing the internet.

Another issue of cabin entertainment system configuration is what content is streamed live to the aircraft, and what is provided from the aircraft's IFE server. The first option for all services to be streamed would require a high downlink rate from the external connectivity system. Streamed movies and visual content could therefore be provided. It saves the airline the cost of acquiring content for the IFE server.

A hybrid of this is for airlines to provide the ability to stream content, but also provide content from an IFE server.

The second option requires a lower downlink rate, but requires the airline to purchase content for its IFE server.

BAE Systems provides its IntelliCabin product for the 737 and 777 families. It is installed on more than 2,000 aircraft. IntelliCabin provides internal and external connectivity for the cabin crew and passengers. BAE Systems works with Samsung to provide mobile tablet devices that can be distributed to passengers, or passengers can use their PEDs.

The IFE content is streamed wirelessly in the cabin using WiFi. BAE Systems explains that this method of providing cabin entertainment is becoming more accepted by passengers, and is cheaper for the airlines.

IntelliCabin further simplifies the cost of providing a system for airlines because it does not use or require any external connectivity. This is because the content is already loaded onto the IFE server, or the tablet devices. The system can, however, be interfaced with Ku- or Ka-band external satcom systems to provide live content or allow the ability to browse the internet.

As an addition to providing the appropriate on-board cabin signals and IFE servers, Honeywell has developed its Ovation Select Cabin Management System (CMS). This digital system integrates with passengers' iOS and Android-powered personal devices. The connection allows each passenger to control a range of systems, such as cabin lighting, window blinds and

The Rockwell Collins embedded PAVES Broadcast IFE system includes touchscreen capability and a range of services from an on-board IFE server. It is provided for the A320 and 737NG/MAX families.

entertainment using their own devices.

The A350 is an example of how aircraft are being configured for cabin connectivity. It will be equipped with Inmarsat SBB, Ka-band Global Xpress provided via Thales, and Ku-band from Panasonic satcom external connectivity. Inmarsat SBB will be used for the cabin crew, while all three will be used for the cabin systems.

There will be a range of services for the passenger cabin. The Airbus-made platform, ALNA, will use the Inmarsat SBB to provide mobile telephone and internet access. The internet can be accessed through cabin WiFi signals, or the aircraft's embedded IFE system.

The Global Xpress provided by Thales will allow the same on-board services that Inmarsat SBB will allow. Global Xpress will have a downlink rate of up to 50Mbps.

The Ku-band provided by Panasonic will also allow the same services. This will also provide EXTV, and the downlink rate of 5-10Mbps is enough for a small number of TV channels.

Thales and Panasonic will both provide six WAPs for the aircraft cabin. This is enough to provide wireless content distribution. These will be used for wireless content distribution, and they will be used to stream content wirelessly from the IFE server to PEDs. This will be in addition to the embedded IFE system.

The content will be uploaded to the IFE server when the aircraft is on the ground through the physical link from a portable data server. Panasonic has a 3G cellular modem, but this will only allow a small amount of content to be uploaded on the ground. Thales has an Aerosync wireless uploading system.

Basic cabin services

E-mail is one of the easiest services to provide, only requiring an external connectivity system with a low downlink rate. Text messaging and voice calls on the telephone come together as one service.

OnAir provides its Mobile OnAir product. "This is through a GSM network on the aircraft that allows the passenger to roam and make calls in the cabin, as they would when they are on the ground," explains Rodriguez. "The system therefore requires no logging on. The airlines generate a revenue stream from this by sharing with us the revenue that they collect from the roaming charges."

Gogo's text and talk product allows passengers to make voice calls and send text messages through the internet via the aircraft cabin's internal WiFi signal. The product is relatively new. It can be used by airlines in the US in conjunction with its ATG product for external connectivity, or in conjunction with satcom by airlines operating in other parts of the world. "There has been a backlash by passengers complaining of being disturbed by people sitting next to them making voice calls. The talk facility is therefore disabled on US domestic flights, and only text messaging is possible," explains Nolan. "The text and talk application can be downloaded by the passenger onto their smartphone prior to boarding the aircraft. This avoids the need for the airline to install any additional hardware on the aircraft, and the existing WiFi signal in the cabin can be used."

GEE also provides a voice call and text messaging service. This is over GSM or WiFi. "This is not the same as OnAir's service, which uses GSM hardware," explains Burhm. "Passengers' smartphones can use either GSM or WiFi, and passengers download the GEE/airline application onto their smartphone so that they can use the GSM capability on their phones over the WiFi signal in the cabin."

E-mail & internet

Similar to text and voice call capability, e-mail and internet browsing is a relatively simple service to provide. It is offered by all IFE providers.

As with its other cabin service products, Gogo provides e-mail and on-board internet either via ATG or through satcom. "The 3Mbps downlink rate provided by the original ATG allows general browsing, but the 10Mbps rate provided by ATG4 allows a more consistent browsing experience," explains Nolan. "Our e-mail and internet service is simple. We provide WiFi in the cabin by providing servers and their related content installed in the avionics bay, and WAPs in the aircraft; and passengers use their PEDs. The product is called Gogo Vision.

"Airlines have the choice of paying for basic internet access and browsing streamed content, or going through the Gogo Vision content, and accessing movies and TV shows on the IFE server," adds Nolan. "Airlines can also ask Gogo to provide additional content, such as shopping. Gogo vision has only been available for two years, but is already used on 1,500 aircraft. The number of aircraft using Gogo vision passed the 1,000 mark at the start of 2014."

OnAir also provides a specialised internet service called Internet OnAir. "This is either a complimentary or paid for service, and is simply a WiFi network in the aircraft cabin for passengers to access," says Rodriguez.

Like OnAir, GEE provides an internet access product that includes a server and installed content, which can be accessed by passengers through their PEDs. Burhm explains that it is also possible to access content that is streamed live to the aircraft.

Rockwell Collins's internet access service works by each passenger downloading the airline's application on to their PED before boarding the aircraft. "This only needs to be done once, and it is up to the airline how they charge for

The highest satcom downlink transmission rates now make it possible for airlines to provide a live streaming service that not only make it possible to provide a large number of live TV channels, but also the streaming of movies from video subscription providers.

it," says Tran. "The passenger can then do several things with their PED, one of which is accessing the internet.

"It is possible to provide music and movies on the aircraft's IFE server, which can be accessed either on PEDs or through the embedded IFE system," continues Tran. "A simple cabin service that relies on passengers using their PEDs means that only a minority will probably have them. An updated or new generation IFE system will have a mix of traditional content and internet connectivity."

Streamed content

Live TV, and access to movies and other content from ground-based sources are the two main cabin services that involve the streaming of live content to the aircraft.

One provider of live TV is Gogo. "Live TV can be provided with a downlink rate of 30Mbps with Ku-band, but a downlink rate of 50Mbps provides a better service for live TV and I.P. TV," says Nolan. "This higher rate will be possible with our Ka-band or new 2Ku-band services that are coming available in 2015. Our new 2Ku-band service will allow the live streaming of video."

GEE offers I.P. live TV. One of its customers, Southwest, provides 15 channels on 450 of its aircraft, in conjunction with its Ku-band external connectivity product.

In addition to Internet OnAir, OnAir has several other internet-related services. "We offer OnAir Play, a streaming service made possible through internal WiFi. The airline has access to a portal where content is displayed," explains Rodriguez. "This includes movies, music and magazines. The content is streamed from the on-board IFE server or streamed live, mainly to passengers' devices. Like OnAir Internet, OnAir Play is charged by the airlines to each passenger, or offered free of charge."

OnAir is also launching a new product called OnAir Plug, which involves an intranet for use by the cabin crew. "It will be used by the cabin crew for administrative functions using iPads, performing live credit card transactions, and sending live reports to the ground," says Rodriguez.

Tran at Rockwell Collins explains that in the US, TV is already broadcast via a dedicated TV satellite, so it can be streamed live to the aircraft. "In many other parts of the world TV is not broadcast via satellite," says Tran. "I.P. TV can be picked up on an aircraft by Ka-band external satcom."

Lufthansa Systems' BroadConnect product provides one of the widest ranges of cabin services. Besides the basics of e-mail, internet access, text messaging and phone voice calls, and access to content on an IFE server, the system also allows live TV and movies to be streamed from the ground. Mueller explains that the downlink rate of Ka-band is enough for live TV, since only 1Mbps is needed per TV channel. "The physical limitations to what can be offered are mainly related to the wireless network in the cabin," says Mueller. "BroadConnect is configured to provide up to 300-500Mbps in the cabin, so live TV is easily possible.

"The external downlink rate and the cabin traffic rate is also high enough to allow streaming of movies and other content from the ground while in the air," continues Mueller. "Our system is the only one that is capable of providing video from servers simultaneously to 250 passengers on board the aircraft. In the case of streamed movies, it is not possible for airlines to acquire the rights to access high definition movies. On average, BroadConnect can deliver 1Mbps per passenger for streamed movies."

ViaSat's high downlink rate of up to 1.2-1.5Gbps to the aircraft is sufficient for live TV services. "The configuration of our system means that we can offer 12Mbps per passenger in the aircraft cabin, so this allows streaming services," says Buchman. "Our customers, such as jetBlue, are experiencing these high rates. The US has a dedicated satellite for transmitting TV, and this is used by jetBlue separately to Ku- and Ka-band external connectivity. Not only are the transmission rates we offer high enough to allow streaming of live TV, but it also makes it possible for passengers to stream movies to the aircraft, for example, from Netflix. The passenger simply has to access their account and subscription via their PED while in-flight.

"jetBlue provides a free basic internet service with our product," continues Buchman. "This includes all internet browsing, including watching short movie clips. The only exceptions are streaming complete movies and films." Other airlines' internet services often charge passengers for a basic service that does not permit access to any moving visual content, such as YouTube videos, and only allows the browsing of static sites or some on-line shopping.

"Passengers on jetBlue pay an access fee of $9 per hour for the internet service that allows the streaming of movies," adds Buchman. "We are catering for a market where passengers can access their own video subscriptions while in the air. Examples include Netflix and the baseball channel MLB.tv.

"Our basic product makes streaming live TV content affordable," adds Buchman. "We have 100% take-up rates by passengers for our complimentary services, and the airlines generate revenues from advertising sponsorships. There is currently low demand for the premium product that allows the streaming of movies, but it is technically and economically possible to offer the service at less than $9 per hour." AC