Developments in air-to-ground and on-board connectivity solutions can have cost, efficiency and revenue-generating benefits for airlines. There has been a growing trend to enable the use of phones, laptops and tablet computers in the passenger cabin. The various solutions are examined here.

Connectivity systems for aircraft

The growing sophistication of consumer-off-the-shelf (COTS) personal electronic devices (PEDs), such as laptops, tablets and smartphones, has corresponded with significant developments in aircraft data connectivity technology. The flightdeck and cabin can be connected while the aircraft is in the air. This can have operational benefits, while also potentially providing additional revenue through the new services on offer. What hardware and service partners do airlines need, and at what cost, to make the most of advances in connectivity?

This article will examine the separate connectivity requirements and methods for in-flight aircraft and aircraft on the ground. It will also consider communication solutions for the flightdeck and the passenger cabin.

The International Civil Aviation Organisation (ICAO) has a system of labelling aircraft communications, or datalink services: safety-critical air traffic services (ATS); non-safety-related airline aeronautical operational control (AOC); and aeronautical administrative communication (AAC).

Cabin requirements will look at crew communications and air passenger communications (APC).

ATS includes safety-critical air traffic control (ATC) communications functions. These include all communications relating to ATC and aircraft separation.

AOC and AAC are used for operational and business purposes and do not influence flight safety. These are operational and administrative air-to-ground communications that are sent between flightcrews and ground-based departments while an aircraft is in the air or on the ground.

APC relates to connectivity services for passengers both air-to-ground and internal cabin communications. These communications enable the use of telephones for text messaging and voice calls, in-flight internet and PEDs.

External connectivity

The main options for connectivity between the ground and an aircraft are radio, satellite, cellular and Wi-fi. Wi-fi is used only while an aircraft is on the ground, at an airport gate. The other technologies are utilised while an aircraft is in the air, but also while an aircraft is on the ground at an airport.

Radio

Radio communication can be used in the air and on the ground. Radio is used by flightdeck crews for ATC purposes. Pilots use very high frequency (VHF) and high frequency (HF) radio to send and receive safety-critical voice messages to and from controllers.

Aside from voice channels, VHF and HF radio can also be used for flightdeck data connectivity. ARINC and SITA have built ground infrastructure that supports the transfer of data in a text format via the aircraft communications addressing and reporting system (ACARS) protocol. This can send character-based messages with a data transfer requirement of 2.4 kilobytes per second (kbps).

In recent years, a new form of digital data radio has been developed called VHF digital link mode 2 (VDLM2), with the ability to transfer data at 31.5 kbps. Messages can be sent in ACARS format using VDLM2, a critical component of European Commission (EC) Controller Pilot Data Link (CPDLC) standards.

ARINC and SITA provide ground infrastructure for communication via VDLM2. In most cases airlines will need to contract with ARINC or SITA for ACARS connectivity via radio.

Satellite

Air-to-ground connectivity via satellite is possible on the ground and in the air. Satellite communication (SATCOM) is a connectivity option for both the flightdeck and cabin, and can maintain an aircraft's connectivity in remote areas when it is out of radio range. There are currently five levels of satellite link available.

Iridium

The cheapest satellite solution on the market is provided by Iridium. "The Iridium constellation consists of 66 satellites in low earth orbit that provide uninterrupted global coverage," explains Brian Pemberton, director of product management for aeronautical and marine products at Iridium. "Iridium has been successful in commercial aviation because of its competitive price point. Our satellites are much closer to the earth's surface than competing solutions. As a result, the antenna required on an aircraft for Iridium connectivity is light and small, roughly the size of a hockey puck. It is a passive antenna, with no moving components and only costs about $500. This is much cheaper than the competition."

Iridium has a data transfer capability of 2.4 kbps with a single antenna. Although it is possible to have multiple antennae, most airlines would use one or

DATA COMMUNICATION SUPPLIERS, COVERAGE & SUITABLE FUNCTIONS

Air-to-ground links	Suppliers	Transfer Rate*	Coverage	Uses
ACARS std (VHF)	ARINC & SITA	2.4KBps	Line of site	Airline operational & admin comms
VDLM2	ARINC & SITA	31.5KBps	Line of site	Required for EC CPDLC mandate
Iridium	Iridium	2.4KBps	Global	Air traffic, operational & admin comms
Inmarsat Classic	Inmarsat	64KBps	Global except poles	Air traffic, operational & admin comms
Inmarsat SwiftBroadband	Inmarsat	432KBps	Global except poles	Operational & admin comms. Pax comms.
Ku band	Multiple	1-2MBps		Admin comms & Pax comms
Ka band (Global Xpress)	Inmarsat	3-4MBps	Global except poles	Admin comms & Pax comms
Cellular	Gogo	-	Over continental US	Pax comms

On-ground gate connectivity	Suppliers	Uses
Cellular		Airport gate communication
Wi-fi	ARINC, SITA	Airport gate communication

Internal cabin connectivity	Suppliers	Uses
Wi-fi	OnAir, Row44, Gogo, ARINC	Browsing internet, emails, instant messaging, streaming media
GSM	Aeromobile, OnAir, Row44	Phone calls, texts, emails, limited internet browsing

Notes: SATCOM transfer rates may vary depending upon the number of channels/antenna fitted. Quoted transfer rates for Ku- and Ka-band are lowest probable performance. Higher rates may be available.

two. Iridium can be used for AOC, AAC and safety-related ATS purposes on the flightdeck, but its limited bandwidth restricts its capability for cabin connectivity. "We do not have the capability to provide high-speed internet for aircraft cabins, but Iridium can support email and text messaging services. There is some evidence to suggest that these are currently the most popular forms of cabin connectivity with passengers," says Pemberton.

Inmarsat Classic & SwiftBroadband

There are two generations of aviation Satcom currently provided by Inmarsat: Inmarsat Classic and Inmarsat SwiftBroadband.

These services are supported by Inmarsat's constellation of geostationary satellites that orbit 26,000 km above the earth. "Inmarsat satellites provide global coverage, except for the poles. This covers the vast majority of the world's air transport routes," explains Miranda Mills, vice president for aerospace, at Inmarsat.

Inmarsat Classic is used on most intercontinental aircraft and, with Iridium, is the only other satellite link operationally approved for safety-critical ATS communications.

Inmarsat Classic can also be utilised for non-critical AOC and AAC functions.

A number of Classic installations also have a capability called Swift64 that provides a data transfer rate of 64 kbps.

The newer generation SwiftBroadband product supports the transfer of up to 432 kbps of data on a single channel, making it a more capable solution for APC purposes. It not only facilitates text messaging and voice calls, but also faster Internet provision. SwiftBroadband does not yet have approval for use for ATS functions, but Inmarsat has a programme under way to get it certified for such by ICAO.

SwiftBroadband can also be used for AOC and AAC purposes.

Ku-band

One capable satellite solution, available internationally, is the Ku-band. Minimum transfer rates are between 1-2 megabytes per second (mbps).

"A number of different organisations invested in placing Ku satellites in space," explains Jags Burhm, vice president for global delivery and sales at Row44. "These were initially intended for live broadcast television. As a number of different organisations have invested in this technology, using Ku-band comes with the benefit of not having to be reliant on, or coupled to, a single supplier." The Ku-band solution is not approved for safety-critical ATS or AOC, but can be used for non-critical AAC purposes. It also represents a step up in cabin connectivity functions. It permits live television in the cabin, advances in internet speed, and voice calls.

Ka-band

The highest capability satellite solution is the Ka-band, with a minimum data transfer performance of 3-4 mbps.

Ka-band is not approved for ATS or AOC purposes, but can be used for both AAC and APC functions.

Inmarsat is working on its own Ka-band product, Global Xpress. This will be available from 2015, and will cover the globe with the exception of the polar regions. "Global Xpress represents a change in capacity," says Mills. "It will be able to provide live TV on board aircraft on a global basis."

"We foresee SwiftBroadband and Global Xpress coexisting," says Dale Irish, head of aero product management at Inmarsat. "Once it receives ICAO approval, SwiftBroadband will be able to provide flightdeck ATS, and AOC functions, while Global Xpress will be the most capable cabin communication solution for passengers. Together they will be a powerful combination ensuring connectivity in all phases of flight."

Inmarsat does not sell bandwidth directly to airlines. It has a number of distribution partners for flightdeck and cabin purposes.

Costs of satellites

"There is a need for caution when estimating the cost for SATCOM hardware, since exact configurations vary," says Ralf Cabos, chief executive officer at Singapore-based aircraft avionics systems supplier Flight Focus.

Cost for the full connectivity hardware package, including an antenna and radio transceiver, could be $8,000-10,000 per aircraft for a single-channel

Flightdeck connectivity is used to send information for both safety-critical ATC functions and non-critical operations and administrative purposes. ACARS is a common method of sending AOC and AAC messages from the flightdeck.

Iridium narrowband solution. For a single-channel 200 kbps SwiftBroadband configuration the cost is likely to be $40,000-50,000, rising to $130,000-150,000 per aircraft for a dual-channel 800kbps SwiftBroadband solution.

A Ku connectivity system is likely to cost $200,000-250,000, while Ka solutions have been slightly higher.

"Airlines also need to consider the full operating cost of SATCOM systems," says Cabos. "This does not only include charges for data bandwidth, but also the potential fuel penalties imposed by the aerodynamic effect of the radome and the weight of SATCOM antennas. These vary considerably in size and weight from a 1.2 kg Iridium connectivity system, to Ku or Ka broadband connectivity systems that weigh up to 100 kg."

Wi-fi

Connectivity with an aircraft via Wi-fi to and from an outside source is only possible when on the ground. While at the gate, Wi-fi hot-spots at airports might be used to download AOC- or AAC-related data or IFE content for the cabin. These are often referred to as Gatelink.

Cellular

A cellular, 3G-style connection is possible while the aircraft is on the ground. In the US, where ground infrastructure is in place across the country, data can also be sent via cellular technology to and from an aircraft while it is in flight.

Gogo uses air-to-ground cellular technology. It built up its client base over the US by using terrestrial cellular towers for aircraft-ground connectivity.

Cellular signals are not allowed inside an aircraft cabin, however, on flights using US airspace. Internal cabin connectivity therefore has to be provided by Wi-fi signals. These allow passengers to access the internet using portable devices.

Flightdeck external

External connectivity for the flightdeck is required for ATC/ATS, airline flight operations and maintenance communications.

Flightdeck connectivity - ATC

There has been a drive to rationalise overcrowded airspace in Europe and the US. The main aims of the Single European Sky ATM Research (SESAR) in Europe and NextGen in the US are to further improve ATC efficiency and safety in some of the world's busiest airspace.

Controller Pilot Data Link Communication (CPDLC), in which routine voice instructions are replaced with text messages, is an important element. Replacing voice instructions with CPDLC requires external flightdeck connectivity.

The EC took a step towards its goal of a single European sky in 2009 by introducing a mandate for Protected Mode Controller Pilot Data Link Communication (PM-CPDLC) in upper European airspace *(see Equipping aircraft with CPDLC to comply with Europe's SES, Aircraft Commerce, October/November 2012, page 27)*. PM-CPDLC is an air-ground datalink application that allows routine ATC tasks to be communicated via pre-formatted text messages rather than voice. It is being implemented by Eurocontrol's Link 2000+ programme.

The basic services that will be performed by PM-CPDLC are ATC communications relating to repetitive frequency changes, ATC clearances providing standard clearance commands, and ATC microphone checks.

The use of VDLM2 radio over the aeronautical telecommunication network (ATN) is the only EU-approved method for sending PM-CPDLC messages between the aircraft and the ground.

"CPDLC messages can also be sent using the Future Air Navigation System (FANs)," explains Chip Meserole, director of advanced air traffic management in the Phantom Works division of Boeing. FANS 1/A can send CPDLC messages over ACARS using VHF radio when in range or Inmarsat Classic or Iridium when in remote or oceanic areas.

Flightdeck connectivity – operations & admin

These communications involve non-safety-critical data transmissions between aircraft and an airline's back office systems or service providers.

Both radio and SATCOM can be used when in the air. The only approved SATCOM links for AOC messages are Iridium, Inmarsat Classic, and Inmarsat Swiftbroadband. They are also used for AAC, but Ku- and Ka-band is also permitted for these purposes.

The most common method of sending AOC and AAC information via datalink for the past few decades has been via ACARS.

ACARS messages can be sent using VHF, VDLM2 and HF radio or approved SATCOM. In most cases airlines will need a contract with ARINC or SITA for ACARS messaging.

"There are dozens of applications you can put across ACARS to help an airline make cost and efficiency savings," says Gary Anderson, business development director, at ARINC Aviation Solutions.

These applications include weather reports, engine data monitoring, fault reporting, gate assignments, galley re-stock lists and the OOOI tool, which stands for the times of Off-blocks, Off-runway, On-runway and In-gate. Recording these times works by sending

There have been various developments in on-board GSM networks and Wi-fi. These services allow the passenger to use PEDs such as phones, laptops and tablet computers while in-flight.

automatic reports as the aircraft reaches each phase, and allows airlines to track progress and keep records of movements.

ARINC identifies the main benefits of ACARS AOC datalink as reduced turnaround, efficient routings around weather, aircraft defects and fault data, and engine health and condition data.

Cathay Pacific has contracted ARINC to equip its aircraft to make air-to-ground transmissions of fault data. Messages will be sent via Iridium and existing ACARS by radio when aircraft are in the air.

"For all ACARS you will generally need a CMU (Boeing) or ATSU (Airbus)," explains Anderson. "These avionics units are the heart of the ACARS system. If sending ACARS by SATCOM, you will need interfacing with SATCOM equipment. For VHF, a third VHF radio is needed on the flightdeck. All aircraft have to fly with two for ATC voice. The third is for ACARS. The same applies for VDLM2. This unit is usually an upgrade of the third VHF radio to a VDL radio."

Electronic flight bag (EFB) technology has increased connectivity options for AOC and AAC purposes. An EFB is an electronic display consisting of the appropriate hardware and software to support various flightdeck or cabin functions *(see The latest developments in EFBs & selection of the right solution, Aircraft Commerce, December 2012/January 2013, page 26)*.

One example of an EFB application is the electronic technical log (ETL). This allows fault data to be manually or automatically entered as a problem occurs. The information can be sent while in flight, and this gives line maintenance personnel the ability to have required parts available upon an aircraft's arrival.

One type of air-to-ground connectivity for EFBs is connection to on-board SATCOM servers via hardwired Ethernet connections.

In this way, it is possible to send AOC or AAC data in document and graphical formats from EFBs using the Internet Protocol (IP) as the message format.

Data from EFBs can also be sent over ACARS as an alternative format. Text and email-type messages are better suited to this format.

When sent using ACARS, EFB data can travel via VHF, VDLM2 and HF radio, in addition to SATCOM.

It can be cheaper to transmit data when on the ground. There is a growing availability of airport gate-based connectivity solutions, such as ARINC's GateFusion product. This uses existing physical Wi-fi infrastructure at airports to allow large data files to be moved from aircraft to ground-based systems.

Internal connectivity

Internal connectivity is for use in the passenger cabin. The two main categories of internal connectivity are for cabin crew performing administrative tasks and for passenger services.

Cabin connectivity – AAC

Airline administrative AAC functions are not restricted to the flightdeck. Their use by flight attendants in the cabin can reduce costs while improving efficiencies.

One solution is ARINC's AirCrew Connect service, part of its CabinConnect suite. It allows cabin crew to use PEDs to replace paper-based processes and send and receive data in flight.

This allows cabin crew to provide instant feedback on customer service issues via a direct link to their offices on the ground. They might, for example, be able to help passengers with onward travel arrangements. At the same time engineers on the ground can be pre-warned of non-safety-related cabin defects prior to aircraft arrival, which could potentially minimise downtime.

Cabin connectivity - APC

Internal cabin connectivity for passenger services (APC) is a fast-growing sector of communications.

The two methods of providing internal connectivity are a global system for mobile communication (GSM) network, and establishing on-board Wi-fi.

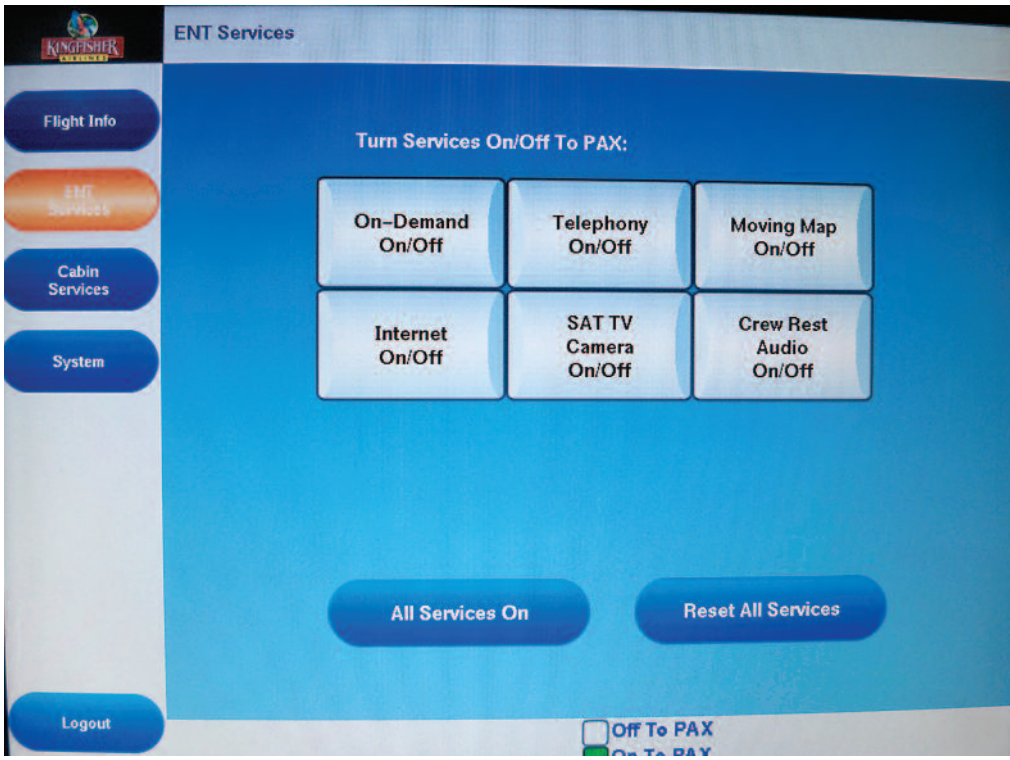
The need for cabin connectivity comes from developments in COTS-based smartphones and tablet devices, which have driven a need to keep passengers connected during flight. Some of the main GSM and Wi-fi service providers in this field are Aeromobile, OnAir, Row 44, Gogo, ARINC, Panasonic and Thales.

Internal cabin connectivity is utilised either by a PED, or via an in-built seatback system.

GSM

A GSM signal in the cabin allows the use of mobile phones and smartphones. However, the use of cellular signals in-flight over US airspace is not currently permitted. On-board GSM services are therefore not possible in US airspace.

"The advantage of the GSM approach is that it is easy for passengers to use. They simply turn their phones on and connect to the network. It allows voice calls, text messages and some data services, but it is convenience at a price," says David Russell, London-based senior vice president of global operations at inflight connectivity provider Gogo. "The disadvantage for the passenger is that they are charged by their normal mobile service providers at roaming rates. The main disadvantage for airlines relates to the equipment required on-board. To establish a GSM network you need a picocell on the aircraft. This acts like a miniature ground station that links data being sent to and from the aircraft's satellite system to the passenger devices. Compared to alternatives, the picocell solution adds cost, complexity and extra



On-board Wi-fi allows passengers to check e-mails, browse the internet, make Skype calls and stream media.

weight to the aircraft."

There are two in-service providers of on-board GSM networks: AeroMobile and OnAir.

AeroMobile

AeroMobile provides an in-flight GSM network, supporting voice, text and mobile data. It can also be used on tablet devices. The AeroMobile GSM service can be used with external connectivity via Inmarsat SwiftBroadband, Ku and Ka satellite bandwidth.

"Using our service is similar to the experience of mobile phone roaming when abroad," explains Kevin Rogers, chief executive officer at AeroMobile. "Provided the passenger has a mobile phone contract that permits roaming, there are no additional set-up considerations to use our service. You just switch on your phone and use as you would when abroad."

AeroMobile has a large number of roaming agreements with global service providers. Passengers are billed by their contracted service providers, which also set roaming prices. AeroMobile then charges that provider an inter-operator fee. The share of the revenue obtained from roaming partners is an incentive for airlines to adopt AeroMobile service.

AeroMobile is part-owned by Telenor and is part of the Panasonic Group, the primary contractor with airlines for the hardware and support services required to operate the AeroMobile service.

"The AeroMobile service is currently active on 140 aircraft across 10 airlines, including Emirates, Etihad and Virgin Atlantic," says Rogers. "We have also seen accelerated growth over the past 12 months, and 2013 promises to be a landmark year for us."

OnAir

OnAir also provides a similar in-flight GSM product called Mobile On-Air. "If offered a choice between Wi-fi and being able to turn your phone on and be instantly connected, 95% of people would choose the latter," claims Ian Dawkins, chief executive officer at OnAir. "Only 10% of these would use the service for voice, while the rest want text and email capability.

"With Mobile OnAir we act like a virtual phone company," continues Dawkins. "We set up roaming agreements with service providers around the world."

As with the AeroMobile product all a passenger needs to use the on-board GSM network is an international roaming subscription. They can then switch on their phones and use voice, text and data services. Roaming prices are set by the passenger's contracted mobile network provider, and airlines get part of the revenue generated by the roaming charges.

Row44

US-based Row44 can also provide an in-flight GSM service. This has been tested and is available on the R44 flying test bed but is yet to enter airline service. Cellular signals cannot be used on US domestic flights, but its GSM service could become an alternative to Aeromobile and OnAir products.

Wi-Fi

A Wi-fi signal allows emails, internet browsing, Skype calls, and streaming media. "The Wi-fi solution requires a router and access points down the length of the aircraft," says Russell. "For the airline it is less costly than GSM."

The three main Wi-fi providers are OnAir, Row44 and Gogo.

OnAir

OnAir has a Wi-fi product called Internet OnAir. By installing a Wi-fi hotspot on the aircraft, users of Internet OnAir are able to use their own personal devices to browse the internet. Passengers pay OnAir for Wi-fi access, and this revenue is then shared with the airline. "We recommend taking both the GSM and Wi-fi products because they each have their advantages," says Dawkins. "If required, we can install both and activate additional functionality at a later date."

OnAir has been operating its GSM- and Wi-fi-based products for four years. It is currently in operation with 28 customers.

Both Mobile OnAir and Internet OnAir use Inmarsat SwiftBroadband to connect the aircraft to the ground. Row44 and Gogo both provide a wireless internet and IFE service, but have used different methods of sending data.

Row 44

Row 44 is part of the Global Eagle Entertainment Group. It provides an enabling platform for media consumption on passenger devices. The platform currently offers high-speed internet, live TV, video-on-demand, games, e-shopping, destination services, an airline portal, and a flight tracker. "Row 44 is providing a wireless media consumption platform," says Burhm. "Our on-board solution allows passengers to use the internet for browsing and/or streaming media to their own devices."

Row 44 utilises Ku-band satellites to provide air-ground connectivity and acts as a wholesaler of satellite bandwidth.

The airline pays Row44 for the connectivity, and is then free to decide whether to charge for the service or provide it free to passengers. "The total service can be used as a means of generating ancillary revenue and act as a service differentiator," adds Burhm.

Gulf Air uses a Ku-band satellite solution to provide connectivity for the flightdeck and cabin. The airline's current level of connectivity has created revenue-generating opportunities in the passenger cabin.

Gogo

Gogo also provides in-flight internet connectivity. "Gogo is essentially an aviation internet service provider (ISP)," maintains Russell.

"Subscribers pay Gogo for use of the Wi-fi service. There are various payment plans, so they may subscribe for an individual flight, or monthly or annually. The airline is responsible for equipping its aircraft with the necessary hardware. To recover its outlay, the airline receives a share of the revenue generated from Gogo. Most airlines recognise the need for cabin connectivity for passenger service and for keeping up with other airlines," adds Russell.

Gogo also offers an IFE service. "The wireless IFE option is a bit like hotel room video-on-demand," explains Russell. "It is possible to purchase content via the Gogo service and watch it on the passenger's own device."

To extend its reach beyond the limits of the continental US terrestrial cellular network, Gogo is rolling out the use of K-band satellites for air-ground connectivity so that its on-board Wi-fi system can be used around the globe.

"Gogo's first satellite system will use Ku satellites, and is currently in testing with Delta," says Russell.

In the future Gogo will be a service provider for Inmarsat's Global Xpress satellite constellation.

ARINC

ARINC, an important player in flightdeck connectivity, also has a cabin product. Its Cabin Connect suite provides on-board Wi-fi via a server and access points. It uses Inmarsat SwiftBroadband, for which ARINC is a distribution partner for air-ground connectivity.

Cabin Connect allows passengers to access the internet through PEDs, and also offers a live credit card authorisation (CCA) function. In addition, ARINC's Live News product can provide regularly updated news, sports and entertainment updates directly to seatback systems.

Thales & Panasonic

Thales and Panasonic both offer seatback IFE hardware. Thales is an end-to-end connectivity solution provider. It can bring together the required hardware, service providers and service level agreements to deliver an airline's required connectivity solution.

The airline experience

Gulf Air has benefited from developing Ku satellite air-ground connectivity designed by Panasonic, for use both on the flightdeck and in the cabin. "In the cabin we have on-board GSM and high-speed internet access," explains Mohamad El Assaad, senior manager of IFE and communications at Gulf Air.

"The GSM service is provided by Aeromobile, and the on-board Wi-fi by Deutsche Telekom. We use Panasonic Ku-band satellites and relevant hardware for air-ground connectivity."

The on-board Wi-fi can be accessed from seatback and PED devices. Upon logging in, passengers are directed to Gulf Air's Skyhub Portal. There are two packages for internet access. Customers can pay $15 for one hour or $30 for 24 hours. These fees can be paid by credit card, with Gulf Air and Deutsche Telekom receiving a share of the revenue.

On-board Wi-fi also permits in-flight retail opportunities. "Our duty-free portal generates large revenues," says El Assaad. "A seatback IFE device is needed to capture the maximum potential market for this retail opportunity."

The bandwidth offered by a Ku-band satellite connection also allows Gulf Air to provide Live TV on-board. This can also be a money-making area with potential advertising space sales during Live TV broadcasts.

"Our current level of connectivity in the cabin means that for the first time an IFE system can generate revenue," says El Assaad. Gulf Air initially focused on connectivity for logistics and security purposes.

Logistics refers to AOC- or AAC-type functions performed on EFBs by the pilots and cabin crew. These are designed to improve efficiencies and cut costs. Examples include sending flight log information and gate data between the aircraft and the ground, or cabin crew reporting. "It is possible to save time on the ground by sending back information on non-safety cabin maintenance issues," says El Assaad.

Summary

Aircraft data connectivity is an embryonic subject and a fast developing area. On the flightdeck, datalink provides safety-critical, air traffic functions. Some are becoming mandatory as Europe and the US seek to further improve safety and efficiency in the skies.

With the introduction of EFBs, flight and cabin crew are becoming increasingly connected for operational and administrative purposes. This can cut operations and maintenance costs, while improving efficiency.

Developments in PED and satellite technology are corresponding with a trend for enabling passengers' carry-on devices in the cabin. In some cases the growing ability to access the internet and stream media to PEDs may negate the need for traditional seatback IFE equipment. At the same time, seatback systems may be the best option for maximising on-line retail opportunities. AC