Many airlines are in the process of improving and selecting their flightdeck connectivity systems. In the meantime, the choice of flightdeck connectivity systems continues to grow. Case studies of which connectivity systems airlines have chosen and how they use them are profiled here.

Airline connectivity case studies

While only a minority of the jet fleet has the latest cabin or flightdeck connectivity systems, more airlines are now updating their fleets, systems and processes. A main objective is to improve flightdeck connectivity to cope with growing volumes of data transmissions and their associated costs. Many airlines are also equipping their aircraft to provide high-volume data transmissions for the passenger cabin to improve the in-service product. The technologies available, and the solutions implemented by some airlines, are examined here.

Data transmissions

There are four categories of flightdeck transmissions. The first of these are air traffic services (ATS) transmissions, which include those made to air traffic control (ATC). ATC transmissions and messages now include controller-pilot datalink communication (CPDLC) messages. All ATS messages relate to safety-of-flight, and generally involve small volumes of data.

The second category of flightdeck transmissions is airline operation communications (AOC) messages, which include: sending aircraft on, off, on and in (OOOI) times; flight plans; engine and aircraft health monitoring (EHM) and (AHM) data; flight data monitoring (FDM); and flight operations quality audit (FOQA) data; central maintenance computer (CMC) and non-CMC fault codes and messages; graphical weather; avionic uploads; and uploads and transmissions from electronic flight bags (EFBs) and electronic technical logs (ETLs) *(see table, page 26)*.

Many of these transmissions involve high volumes of data. AHM and EHM data downloads are increasing, and each aircraft can typically download 1-3 megabytes (MB) of data per month.

The FDM, quick access recorder (QAR) and FOQA data are even larger, at 200MB to 2.0 gigabytes (GB) per aircraft per month. Airlines also have to regularly upload navigation database revisions, of 2MB or more, to the aircraft.

Another category of AOC messages that involve large data volumes are uploads to revisions for the EFB, such as new chart databases.

EFBs can be operated with no air-to-ground connectivity, and so are standalone devices. With real-time air-to-ground connectivity, they can send and receive messages to and from the ground.

The third category of flightdeck transmissions is airline administrative communications (AAC), including crew rosters and manifests, and navigation chart and aircraft loadsheet uploads *(see table, page 26)*. These therefore involve large volumes of data.

The fourth category of flightdeck transmissions is air passenger communications (APC), which transmit items of interest to passengers.

AOC, AAC and APC are not related to the safety of flight, but can involve large volumes of data.

Traditional connectivity

The traditional connectivity systems for flightdeck transmissions are very high frequency (VHF) and high frequency (HF) radio for voice transmissions for ATC, and the aircraft communications addressing and reporting system (ACARS) for sending and receiving data and text transmissions. ACARS, available since the late 1970s, was originally sent via VHF and HF radio. It was used to supplement radio voice transmissions, or provide an alternative to them. The transmission rate of 'plain old ACARS' over VHF or HF radio is 2.4 kilobits per second (kps), while the transmission rate of ACARS over second generation VHF digital radio is 31.5kps.

'Classic' satellite communication (Satcom) based on L-band frequencies were introduced by Inmarsat in the 1990s, and by Iridium in 2011 for commercial jets. These can be used to transmit all four categories of flightdeck messages. These can be in ACARS format, and the prime reason for its use is ATS messages. The transmission rate of ACARS over L-band satcom is 2.4kps.

ACARS is a robust and reliable flightdeck transmission system. Its drawback, however, is that it has a low transmission rate over VHF or HF radio, or over L-band Satcom.

ATS data messages are relatively low volumes, so the traditional radio and Classic Satcom connectivity systems are generally considered satisfactory. AOC, AAC and APS data transmissions involve larger volumes of data, however. Many of these are being sent via ACARS.

AOC transmissions include large volumes of AHM and EHM data, and other uploads and downloads of larger magnitude. Many airlines are still sending AHM and EHM data in real-time via ACARS using the traditional connectivity systems of radio and L-band Satcom. This is expensive, and airlines can pay $3,000-4,000 per month per aircraft.

Alternative connectivity

There are generally two options available for making non-ATS and non-safety-related transmissions. The first is for a lot of AOC data, especially AHM and EHM, to be sent in real-time and during flight using a connectivity system with a higher bandwidth and faster transmission rate. These systems with higher data transfer rates are new generation air-to-ground satcom systems, intended to make it cheaper to send data in real-time, rather than via traditional connectivity systems.

The second option is for airlines to send only the data that must be sent in real-time. This is a minimal amount of

CLASSIFICATION OF FLIGHTDECK MESSAGES & COMMUNICATIONS

Message category	Message type
ATS	Short-range ATC communications
	Long-range ATC communications
	Short- & long-range CPDLC messages
	Short-range FANs-2/B+ position in EU airspace via CPDLC
	Long-range FANS1/A position reports via CPDLC
	Recorded ATIS messages
	Recorded DATIS messages
	Pre-departure clearance
	FL & track changes
	Trans-oceanic clearances
	Trans ocean/long-range position reports & related information
	Overland/short-range position reports & related information
AOC	OOOI times
	Flight plans
	EHM & AHM data
	FMS database uploads
	CMC fault codes & non-CMC fault codes, ETL transmissions
	Graphical text weather services
	EFB uploads & downloads
	Crew messages
AAC	Crew manifests & rosters
	Medical airport requests
	Chart & loadsheet database uploads
APC	News & other items of interest to passengers

data transmissions, including: all ATS-related messages; and only the AHM and EHM parameters related to emergency and safety issues, such as exceedences in engine operating parameters.

The rest of the data can be sent when the aircraft is on the ground, using new generation satcom systems, or on-ground WiFi and cellular connectivity systems.

Avionic architecture

New-generation satcom systems, on-ground connectivity systems and some of the avionic units in modern aircraft types operate on internet protocol (I.P.), rather than ARINC protocol.

Legacy aircraft are equipped with avionics that only work on ARINC protocols, so all four categories of flightdeck transmissions must be made via ACARS through radio and L-band satcom, because radio and L-band satcom send messages in ARINC protocol.

ACARS messages, which can originate from a number of avionic units, are sent from the air traffic service unit (ATSU) in Airbus aircraft, the communication management unit (CMU) in Boeing aircraft, or the equivalent box in other manufacturers' aircraft. The ATSU and CMU are then interfaced with the VHF and HF radios, or the L-band satcom connectivity systems.

Avionic units that operate on I.P. are linked via an ethernet. New-generation satcom systems also send data and information in I.P., so they have higher transmission rates than ACARS over VHF or HF radio, or L-band satcom.

Despite the advantages of high-speed transmission rates, I.P. transmissions are not certified to carry safety-related ATS messages. The larger volume AOC, AAC and APC messages can, however, be sent over the I.P. connectivity channels that have higher transmission rates.

Legacy aircraft can be retrofitted with aircraft interface devices (AID) avionic units to convert data between the ARINC and I.P. protocols. An avionic vendor that provides such units is Cobham. Cobham's Aviator S for Safety product is an avionics unit that encapsulates ACARS messages in I.P. packets, and sends them over an I.P. connectivity system. Some of these devices have begun to be used by a small number of airlines.

This is in parallel with more aircraft being retrofitted with modern generation connectivity channels, which will be used for the AOC, AAC and APC messages.

Airlines can still send ATS messages in ACARS, via the ATSU or CMU, through traditional radio and L-band satcom.

A legacy aircraft that has been retrofitted with interface devices and has multiple connectivity channels, therefore needs to be able to determine which transmissions should be sent via which connectivity channel at every stage of the flight, and wherever the aircraft might be located at the time. This can come in the form of specialised units that can be programmed, for example, to distinguish between which messages and data should be sent in real-time, and which should be sent after the aircraft has landed.

Modern aircraft types, such as the A380, 777, 787 and A350, have been configured with on-board servers. These were optional on the 777, and not all airlines chose to have them. On-board servers provide interfaces between ARINC- and I.P.-based avionics. This allows data to be converted between the two formats, and so passed between the two types of units. They therefore perform the same task as AIDs on legacy aircraft, but at a higher level. Servers also interface with the aircraft's connectivity systems, and select the cheapest and most appropriate one at the time.

Modern aircraft types therefore have more flexibility regarding the connectivity systems they can use.

There is also the option for legacy aircraft, with avionics based on ARINC protocols, to be retrofitted with servers that allow data from these avionic units to be converted to I.P. protocol. These will use higher-bandwidth connectivity systems, which would reduce the cost of transmissions. A server also provides an interface between ACARS and these modern connectivity systems, so airlines can send more non-ATS transmissions in real-time, relatively cheaply.

A server also provides a channel for large data uploads, for items such as navigation databases and EFBs.

Another option is to use EFBs as servers on the aircraft. These are interfaced with the avionics via an A.I.D. unit, and with a variety of connectivity systems. The EFB, and various interface devices, will also include the conversion of data between ARINC and I.P. protocols and formats.

Airlines also need to decide how to establish EFB connectivity or to manage the different levels of messages, and choose the right connectivity channel. Rockwell Collins ARINC offers a communications platform known as AeroSync to meet this need. This is a high availability service that manages, in real-time, bidirectional message traffic and data transfers between the aircraft and the ground, across multiple air/ground networks based on a configurable policy. It links legacy flight operations communications channels with new-generation connectivity systems.

Aerosync converts data between ARINC and I.P. protocols, identifies the category and relative priority of flightdeck messages, determines whether the message needs to be sent in real-time or later, and selects the most appropriate connectivity system. The transmissions will be sent to and from the aircraft in a mixture of ARINC and I.P. protocols.

The Aerosync system manages data delivery by the aircraft. "Aerosync can be used uniformly across several aircraft types," says Declan Boland, senior director, Rockwell Collins ARINC eEnabled Aircraft Solutions. "Each aircraft type in an airline's fleet is

When selecting flightdeck connectivity systems, airlines have to start by deciding which system to use for ATS messages; whether AOC, AAC and APC messages should be sent in real-time or sent when the aircraft is on the ground; and what is the most appropriate combination of connectivity systems to equip their fleet with.

configured and upgraded differently. Aerosync enables holistic air-to-ground management of all avionic-connectivity system interfacing and management of transmissions for all aircraft types in an airline's fleet. This means that an airline does not have to find an interface and transmission management solution for each connectivity system retrofitted to an aircraft type on an individual basis."

On-ground connectivity

There are few limitations relating to which categories of flightdeck messages can be sent on the ground. On-ground connectivity systems have higher transmission rates than any air-to-ground connectivity system.

On-ground systems are now popular because of the growing volumes of safety-related data that have to be sent, as well as increased numbers of data uploads and downloads for EFBs and ETLs.

Teledyne Controls' cellular WGL unit has a transmission rate of 100 Kbps for uplink, and three or four times that rate for downlink. Its more advanced WGL Comm+ unit has an uplink transmission rate of 23 Mpbs, and a downlink transmission rate of 84 Mbps. Their high transmission rates allow large volumes of data to be transmitted relatively cheaply.

Satcom systems

There are several new generation satcom systems available.

There is a widely held, and incorrect, view that cabin connectivity systems must differ from those used for the flightdeck.

Ka- and Ku-band are high bandwidth systems that provide high transmission rates for aircraft. Ku-band is provided by GoGo, Row44, LiveTV and Panasonic. It has a transmission rate of at least 1-2 megabits per second (Mbps). Ka-band is provided by Inmarsat, and has a higher transmission rate of 3-4 Mbps.

Ka- and Ku-band are used by many airlines to provide services in the cabin, such as live TV and internet browsing. Ka- and Ku-band waves get attenuated by water droplets, however, so they are not approved for ATS-related transmissions and messages, but they are approved for AOC, AAC and APC messages. Singapore Airlines (SIA) has Ku-band supplied by Panasonic. The Ku-band is segregated into two channels, one for the flightdeck and one for the cabin. SIA uses the cabin channel for AOC, AAC and APC transmissions.

Many airlines consider sharing a Ka- or Ku-band connectivity system for flightdeck and cabin transmissions to be necessary to make it cost-effective.

There are several other options for air-to-ground connectivity. The first satcom system to become available after Classic L-band options is Inmarsat's swift broadband (SBB). SBB has a transmission rate about 40 times faster than L-band satcom: 432 kbps. This faster rate is because SBB transmissions are in I.P. protocol, and so are not limited to the transmission speeds of standard ACARS over radio or L-band. SBB is already approved to send AOC, AAC and APC messages, which can be in I.P. format.

SBB is due to be approved to send ATS messages in late 2015. ATS messages, including ACARS transmissions, will be sent via SBB in an I.P. 'packet' or envelope on the aircraft in a purpose-built avionics device. An example is Cobham's Aviator S for Safety unit, whose prototype is now being tested. Once received on the ground, the ACARS messages are unwrapped, and fed into the ACARS messaging network. This will overcome the bottleneck of sending ATS messages over L-band.

Many airlines prefer a single system that will allow some cabin connectivity in addition to flightdeck transmissions. However, some will be able to justify a separate satcom system for flightdeck communications. SBB will be suitable for future air navigation system (FANS) 1 operations, once it has been approved for safety-related ATS messages.

Inmarsat has recently launched a new product called S-band, available for use in EU airspace. "The EU has given Inmarsat access to a new type of satcom system, and we will use a spectrum of frequencies to provide a complementary terrestrial-based network in Europe," says David Coiley, vice president of aviation at Inmarsat. "This will be similar to GoGo's air-to-ground (ATG) service, which provides for cabin connectivity in the US. Our new S-band product will use air-to-ground transmissions via ground-based transmitters and S-band satellites to provide a 4G system that will have a transmission rate of 100Mbps. This will provide external connectivity to provide cabin services together with AOC, AAC and APC flightdeck transmissions.

"The S-band satellites and ground-based transmitters will complement each other," continues Coiley. "The large areas of Europe over water such as the North Sea and the Mediterranean mean that the ground-based transmitters will not provide complete connectivity for an entire flight for every possible trans-European route. The S-band satellite connectivity will therefore have to supplement the ground transmitters in certain cases. This new S-band service should have a higher transmission rate than Ka-band, which has a higher transmission rate than Ku-band."

Iridium is developing several new products, including its Open Port service, a high-speed version of its classic L-band. This will be used for I.P., and data and voice, transmissions. The data transmission rate is up to 134 Kbps. It can be used for high-volume non-ATS transmissions, such as EFB uploads.

Another new Iridium service, 'Iridium NEXT', will be available from 2016, and

Norwegian Air Shuttle has equipped its fleet with Panasonic Toughpads for use as EFBs and ETLs. These devices have internal modems that can connect to 3G/4G cellular networks when on the ground at airports. This makes it possible to upload software and make other file transfers.

be used for sending ACARS safety-related messages that will be encapsulated in I.P. packets. This is similar to Inmarsat's ACARS via SBB service, but it will have a transfer rate of 1.5 Mbps.

Flightdeck case studies

Airlines need to consider all the different types of flightdeck communications in small groups when selecting a connectivity system, rather than choosing a single one. An important issue has been connectivity for messages and data transmissions to and from EFBs. These are AOC communications.

Norwegian

Norwegian Air Shuttle considered various options for establishing connectivity for its EFBs and ETLs. Its destinations are major airports in the EU, plus some major airports in the US on its long-haul network.

Norwegian uses Row44's Ku-band service for external connectivity and its WiFi for internal cabin connectivity for its passenger services. "We tried using the two systems to establish connectivity for the EFBs and ETLs," says Klaus Olsen, EFB manager 737 OPS flight support at Norwegian. "The problem was that the external Ku-band connectivity was unstable because it suffers from attenuation by water droplets in the air.

"We looked at using 3G or 4G cellular connectivity. Our EFB devices are Panasonic Toughpads," continues Olsen. "These have internal modems, so they are able to connect to the 3G/4G cellular networks at all the airports we operate to. Connectivity for EFBs/ETLs can therefore be established when the aircraft is on the ground, so our operations staff in their office can log onto the aircraft remotely, through the Toughpad, when the aircraft is on the ground at any one of our destinations, because all the airports we operate to have a cellular network.

"We chose the Panasonic Toughpad over an iPad for the EFB, because it is not possible to log onto the iPad remotely in the same way," says Olsen. "The content on the device can be viewed, and decisions made about a need to update. Problems can also be analysed. It is also possible to make file transfers, such as uploading software. The content can also be synchronised very easily."

Olsen says a 50MB update can take 10 minutes when an aircraft is on the ground. If the aircraft is at an airport with no connectivity, the pilots can use the WiFi connectivity at their hotels. The data are downloaded onto a laptop, and then onto a USB drive, which can be taken to the EFB and uploaded.

easyJet

easyJet has several connectivity systems for its flightdeck and operational purposes. It has connectivity programmes for its EFBs, flight operations and AOC data in process.

easyJet selected Panasonic Toughpads for use as EFBs, which have already been deployed on the A319 fleet. "Pilots use these to perform take-off calculations and other operational functions. Content is updated every 14 days," says Anthony Spouncer, senior project manager at easyJet. "The Toughpads have an internal modem for 3G connectivity. This is currently disabled, but we will start using it in 6-12 months. We would like to do all updates in one go, but the data volumes are large. We would also like each EFB to communicate with a central portal when it has been updated, and notify what version of the software it has installed.

"We currently use a DVD or Blu-Ray disc to perform a full system update, and this involves up to 12 giga bytes (GB) of data," continues Spouncer. "This update is manually performed on the aircraft, during an overnight line maintenance check. The EFB's entire content is updated in one go to be sure that we do not make any errors. In future we want to do delta changes wirelessly, using the 3G or 4G cellular network or WiFi on the ground at the airports, and the internal modem in the Toughpads. Delta changes are required when a software or chart update comes due."

easyJet already has Teledyne Wireless GroundLink (WGL) boxes installed in the avionics bay of its A319 fleet. "In future we could connect the two Toughpads on the flightdeck to the WGL unit, so the WGL would communicate wirelessly on the 3G network, and perform all uploads and downloads," explains Spouncer. "It is simpler, however, to connect the Toughpads wirelessly directly to the 3G cellular network, and then perform the data transfers. We will, however, look into upgrading the WGL units to being WiFi-capable, because we are currently using the WGL units to download safety-related FDM and FOQA data when the aircraft is on the ground."

Prior to operating the A319, easyJet operated 737-700s, which were not equipped with ACARS, so the airline made most AOC, AAC and APC reports manually on paper records. In 2004, easyJet switched to the A319, which was equipped with ACARS. "We have been using ACARS since then to transmit a large number of different AOC and AAC messages, especially AOC," says Taylor Bradbury, aircraft operations support systems manager at easyJet. "Up to 30 different types of AOC messages are sent per event or flight, or daily. The AHM and EHM data are sent daily. The WGL unit provides cellular on-ground connectivity, and transmits FDM and FOQA safety-related data. This comes under Airbus AirFASE terminology. The data are sent when the aircraft makes a connection on the ground."

The amount of data easyJet transmits via ACARS has crept up over the years, and it is now considering whether a new connectivity system should be used. "We

easyJet has several connectivity systems for its EFBs and various flightdeck messages. The airline selected Panasonic Toughpads for use as EFBs on its A319 fleet. These have internal modems. It plans to make periodic updates to the content on EFBs wirelessly. It also uses a WGL unit to transmit large volumes of AOC data via a cellular network.

have divided the AOC and AAC messages into two groups," says Bradbury. "These are messages that do need to be sent in real time, and those that do not, such as the AHM and EHM data, journey logs, OOOI times, and fuel data that must be transmitted for us to comply with the EU's Emissions Trading Scheme (ETS).

"In future we will only send data via ACARS that will be used and processed," continues Bradbury. "Data that do not need to be transmitted in real-time will be sent post-flight, possibly via a WiFi connectivity system, either direct from a WiFi unit to the WiFi network on the ground at airports, or via the Toughpads that we are already using for EFBs on the flightdeck. The aircraft are equipped with a flight data management interface unit (FDMIU) from Teledyne Controls. This interfaces with the A319's air traffic service unit (ATSU), which uses ACARS to send messages in real-time; and the WQAR, which sends data by WiFi when the aircraft is on the ground. The FDMIU decides which messages to send in real-time or via on-ground connectivity."

easyJet ultimately wants to have an air-to-ground connectivity system for the flightdeck and the cabin. "We have not yet chosen a system, but we will not use any of the current satcom systems," says Spouncer. "The antenna for classic Ku-band, for example, is large and results in a lot of drag that significantly increases fuel burn. The new Ku-band system has a smaller antenna, however. We must also consider a connectivity system's three man costs. These are installation, fuel and weight penalties, and the on-going costs of communication."

easyJet will also use the new flightdeck connectivity system to increase the volume of AAC and APC transmissions. AAC messages will include charts, crew briefings, and e-tech logs. APC messages will include hotel and car hire bookings and reservations.

Cathay Pacific

Cathay Pacific is implementing its plan for the full-time global connectivity of its fleet. Each aircraft will be connected network-wide during all phases of flight and during ground servicing. The process has started with equipping three 777-300ERs with a terminal wireless LAN unit (TWLU) to provide WiFi on-ground connectivity, and Iridium L-band satcom and ACARS via VHF and HF radio connectivity systems. USB ports are available as a back-up to upload and download data. The three connectivity systems will be supplemented later with on-ground cellular connectivity primarily for Cathay's home port.

In the case of the future 3G/LTE cellular on-ground system, there is the possibility of a single provider offering a global service at all airports. This should make the system easier for the airline to manage and cheaper to subscribe to.

"These four connectivity channels will allow three types of flightdeck transmissions (AOC, AAC and APC). ATS messages can still be sent by VHF and HF radio, Iridium," says Rob Saunders, head of engineering cost management & business improvement at Cathay Pacific. "Messages will be sent via the ARINC Aerosync system, developed by Rockwell Collins, with airborne e-enablement specifically in mind."

Cathay Pacific's concept is elegantly simple. It comprises four DAC EFBs networked via a combined ethernet switch and AID. The AID, provided by Ballard, allows data to be converted between ARINC and I.P. protocols transmission between the aircraft's avionics and the e-enabled network. The Ballard unit also uses the most appropriate data path, for each message transmission, based on urgency, bandwidth requirement and cost.

The design, therefore, does not require an OEM-installed server to be retrofitted to all of Cathay and Dragonair's aircraft. Instead, two of the four EFB remote processor units (Windows-based computers) are configured as servers. As well as the EFB programme manager, applications such as NavTech's charts and Ultramain's technical and cabin logs are hosted centrally for access on the flightdeck EFB displays, as well as on mobile devices in the cabin via two cabin wireless LAN units (CWLUs) for operational use only. Three of Cathay's 777-300ERs are operating in parallel with an existing process to gain paperless operations approval from Hong Kong's civil aviation department by year end.

"The TWLU will allow us to use a Terminal WiFi service. That is, the TWLU on the aircraft communicates with a ground ARINC terminal wireless system called Gatefusion. The data transmissions will be hosted by ARINC and provide a ground terminal wireless system called Gatefusion," continues Saunders. "All the data sent from the aircraft will be channelled to ARINC's Annapolis facility, and then sent to Cathay Pacific for processing. We only plan to use the Gatefusion service at our Hong Kong (HKG) base for now, until the 3G/LTE equipment is installed on the aircraft."

Initially, Cathay is using the Gatefusion service to provide software and chart uploads wirelessly at HKG. This will be expanded to loadable software as a part (LSAP) and field loadable software (FLS) uploads and QAR downloads when the system is deployed more widely across the fleet. The system is in the operational approval process, which started 1st of July 2014.

"The key to a successful migration away from paper is to recognise that we do not operate in a perfectly connected world," says Saunders. "We have chosen e-enabled applications that are designed for operational continuity, even if an aircraft has a connectivity failure."

Cathay has included failure modes in

Cathay Pacific is in the process of implementing its plan to establish full-time connectivity for its fleet. This will be achieved by equipping its aircraft with a TWLU, to provide on-ground WiFi connectivity; Iridium L-band satcom; and ACARS via VHF & HF radio. These channels will be used to transmit AOC, AAC & APC messages in all phases of flight.

to its system, however, including a back-up paper process on an individual aircraft basis. "We chose to install a hardwired EFB display in the cabin specifically for cabin crew use, with a failure of the cabin wireless in mind. Some flightdeck applications can also be accessed from the cabin unit for maintenance personnel use," adds Saunders.

Cathay's design goal was full-time global connectivity. Selecting Iridium L-band meets this goal due to Iridium's use of orbiting satellites, which ensure global coverage, including the growing number of trans-polar routes operated by Cathay. The Iridium antenna is much lighter than the previous satcom system that has been removed for weight and drag saving.

The third option is to make transmissions via ACARS over VHF. This will only operate when the aircraft is in line-of-sight with ground-based transceivers. "The Ballard avionic unit will choose the cheapest and most suitable connectivity channel to use," says Saunders. "Iridium, for example, may not be cheaper than ACARS over VHF in certain situations. Iridium clearly has a larger bandwidth, so we do not want large data volumes to be transmitted over VHF or HF. We have configured the system so that Gatefusion is used to send all data that are not sent in real-time, including large transmissions that relate to AOC. These are charts, flight manuals and software updates."

Cathay Pacific has yet to decide how it will download AHM and EHM data in the future. "These data are currently being sent via ACARS, but we will look at which connectivity system to use later in this project," adds Saunders. "We have seen large OEM-driven increases in data volumes from later aircraft types, so the method of downlinking this data is an obvious target for future cost savings if it can be moved to Gatefusion.

Cabin connectivity

The main types of passenger cabin connectivity are WiFi and cellular signals to allow live television, internet access, the ability to send and receive e-mails, and the use of smartphones.

These are all made possible through the use of high bandwidth satcom and cellular systems for external connectivity between the aircraft and the ground.

The main types of external satcom connectivity are Ka-band and Ku-band, which are available globally. They provide high bandwidth, which is needed to provide the internal cabin connectivity services for a large number of airlines. Ka- and Ku-band transmissions do get attenuated by water droplets, however, so they can be interrupted by weather patterns. Ka-band is provided by GoGo and Inmarsat, while Ku-band is provided by Hughes, EUTEL, Intelsat, SES, GoGo, Panasonic and several other providers.

GoGo is developing a new satcom product called 2Ku-band, which was launched in April 2014. This will feature two small low-profile antennas on the outside of the aircraft. 2Ku-band is based on spotbeam technology provided by Intelsat and SES. One antenna will receive transmissions of up to 70Mbps, initially, rising later to more than 100Mbps. This will provide larger bandwidth for improved cabin services.

A third main type of external cabin connectivity is terrestrial air-to-ground (ATG) cellular technology. This is provided by GoGo over the US to and from the ground, from more than 200 transmitters in the US, Canada and Alaska. These provide complete connectivity over North America. The original system was capable of a transmission rate of about 3Mbps.

GoGo's second generation system is capable of up to 10Mbps. Its third generation system will be ATG V 4.0, which will use three times the bandwidth, and so provide more capacity per aircraft.

GoGo has so far equipped more than 2,000 aircraft in North America with the original ATG, Ku-band and ATG 4.0. These include aircraft operated by Delta, American Airlines, Virgin America, United Airlines, and Alaska Airlines.

GoGo provides external and internal connectivity. Despite GoGo's ATG being based on cellular signals to the aircraft, cellular signals are not permitted inside the aircraft cabin when operating over the US. GoGo consequently provides internal WiFi signals in the aircraft cabin. This requires an airborne central processing unit (ACPU), a modem, and wireless access points to be positioned in several parts of the cabin.

GoGo's WiFi cabin signals allow it to offer several products. It originally offered a telephone roaming service in the cabin, but there was a consumer backlash against people talking on the phone. It now has a new product called 'Text and talk'. The talk facility is turned off on US domestic flights, while the text facility can still be used.

GoGo's WiFi product is primarily used by passengers to access the internet, and send and receive e-mails. GoGo does not yet offer live television, but this will be possible with 2Ku-band.

Row44 also provides internal cabin connectivity. It packages the service for its airline customers, which charge subscription fees to passengers. Its high-speed internet service is currently installed on 525 narrowbodies, and used together with Ku-band external satcom connectivity. It estimates that 800 aircraft are equipped with Ku-band, of which 250 are used for long-haul operations.

Row44's intranet service allows passengers to access live television, the internet and video on demand. It is used by Southwest, Norwegian Airlines, Transaero, Mango and Icelandair. AC