New-generation flightdeck connectivity systems are coming into service, and promise to provide flightcrews and airline departments with a scope for a wide range of performance-enhancing applications.

Broadband flightdeck connectivity systems & their applications

New-generation flightdeck connectivity systems have the ability to transform flightdeck and airline operations by providing higher rates of data transmission via an I.P. communication link to and from the flightdeck. These are media independent aircraft messaging (MIAM), Inmarsat swift broadband (SBB), Iridium NEXT, and K-band satellite communication (satcom) systems. The transmission of air traffic services (ATS) messages using Inmarsat SBB, for example, will be permitted from late 2016 or early 2017. The SB system is already approved for all other categories of flightdeck transmissions.

The high data transmission rates, or bandwidth, of these new connectivity channels will make possible new applications and flightdeck functions for the first time, including: electronic flight bags (EFBs); the transmission of a larger quantity of more detailed data to and from an electronic technical log (ETL) hosted on an EFB; live and detailed graphical weather (Wx) data; a larger volume of aircraft (AHM) and engine health monitoring (EHM) data; and live video transmissions from the flightdeck to airline departments. These new connectivity channels will also lead to the development of other applications and uses in the future.

Flightdeck communications

There has been little evolution of flightdeck connectivity systems over the past three to four decades. Radio systems for voice, data and text transmissions, as aircraft communications addressing and reporting system (ACARS) messages, were limited to analogue and digital communication via very high frequency (VHF) radio over short distances and via high frequency (HF) radio over medium and long distances.

ACARS transmissions via first-generation analogue VHF and HF radio systems are limited to a data transmission rate of 2.4 kilo bits per second (Kbps). ACARS transmissions via second-generation VHF radio have a higher data transmission rate of 31.5Kbps.

The advent of the future air navigation system (FANS) in the late 1980s/early 1990s for long-haul aircraft operating over oceanic and remote areas was partly intended to replace position reporting via voice calls over HF radio with text and controller-pilot data link communication (CPDLC) messages via ACARS over satcom.

The satcom systems used for the ATS transmissions are L-band transmissions. The two L-band satcom systems used in FANS are Inmarsat Classic and Iridium Classic. L-band satcom systems are approved for ATS transmissions because they provide secure connectivity links that are not interrupted or lost due to weather.

Data ACARS transmissions via L-band satcom have similar data transmission rates to analogue ACARS transmissions via VHF or HF of 2.4Kbps. This is sufficient for CPDLC transmissions.

These six legacy connectivity systems have limited the quantity of data and information that can be transmitted economically to and from the flightdeck, but are the only systems that are used by the majority of airlines.

Flightdeck transmissions.

Flightdeck transmissions fall into four categories.

The first category comprises ATS transmissions, which are voice calls or ACARS messages between the aircraft and the ANSPs.

ATS transmissions all relate to ATC and navigation, so they require secure connectivity channels. To date, analogue and digital VHF and HF radio, and L-band satcom systems are the six connectivity systems approved for ATS transmissions.

The second main category of flightdeck transmissions is airline operational communication (AOC) messages. These are communications between the aircraft and airline departments, such as maintenance control and flight operations. AOC messages do not need to be transmitted via channels approved for ATS transmissions.

There are several categories of AOC messages. They include AHM and EHM data, some graphical and textual weather data and information that can be sent to an EFB system on the aircraft, and central maintenance computer (CMC) fault codes sent from the aircraft to the operator's engineering department.

The small amount of health monitoring and performance data that has to be transmitted from an aircraft in real time relates to emergencies and performance exceedences, such as excessive engine exhaust gas temperatures.

Airlines have, however, traditionally transmitted EHM data for all engine parameters in real time via legacy connectivity systems, regardless of when the data are analysed. The number of engine health parameters monitored has gradually risen, which has increased the cost of making these AOC communications.

There are also airline administration communication (AAC) and airline passenger communication (APC) messages, which may be sent by a cabin EFB used by the flight attendants. However, these are relatively small in volume.

Airlines have traditionally have only been able to provide their flightcrews with WAFC weather forecasts, which are generated every six hours, for the entire duration of the flight. New-generation, high broadband flightdeck connectivity systems make it possible to provide pilots with real-time weather updates via EFBs.

EFB evolution

The advent and development of EFBs has seen them perform a steadily increasing number of functions.

EFBs replace large volumes of paper maps, charts and manuals with electronic versions, and host applications for making performance and other calculations. In most cases, these functions have not required the EFB to be connected with the aircraft's external connectivity systems.

EFBs can now host ETLs and send a variety of messages to airline departments on the ground. This does require the EFB to be linked to the aircraft's external connectivity systems.

Most airlines operate with what were previously referred to as Class 1 non-mounted and Class 2 mounted EFBs. These are based on commercial off-the shelf (COTS) devices.

Class 3 devices are EFBs installed on aircraft as part of its avionics.

The three EFB classes have different levels of software: Type A, B and C.

Type A software is non-interactive with the user, which means that the EFB is used only as a document reader for items such as maps, charts, operating manuals and other pilot briefing documents.

Type B software refers to applications that are used interactively by the user. These applications include ETLs and applications with functions such as performance and take-off, and weight and balance calculations.

It should be noted that Class 1 EFBs are legally limited to use during the non-critical phases of the flight, including take-off, initial climb, approach and descent. In many jurisdictions Class 1 EFBs can only be used above 10,000 feet, so they are restricted to use with Type A software both during cruise and at pre-departure, and with some Type B applications, such as take-off performance calculations, and weight and balance sheet and the loadsheet when on the ground.

An ETL application, for example, may be of little benefit to the crew, since it cannot be used in all phases of flight, and the crew are still required to carry printed paper charts and manuals on the aircraft for use during the critical phases of flight.

The information used on Class 1 EFBs for performance calculations is read from the aircraft's avionics and FMC/FMS by the crew and then manually entered by them into the EFB before aircraft departure.

Class 2 EFBs are mounted on the flightdeck, and their use is permitted in all phases of flight, so they are free to use all types of Type A and Type B software.

The first implication of this is that all types of manuals, maps and charts can be viewed on screen for all phases of flight, so no paper has to be carried on board.

A main feature of Class 2 EFBs is that they can have either a one-way or two-way data connection with the aircraft's avionics and systems.

A one-way data connection allows data to be passed from the avionics and computers to the EFB, but not in the opposite direction. This would allow data from the FMS, for example, to be sent to the EFB for use on the performance calculation application.

A two-way connection between the aircraft's avionics and the EFB would permit an improvement in operability in several ways. This is because the EFB would be able to send data to the aircraft's avionics, while being connected to the aircraft's communication management unit (CMU) or air traffic service unit (ATSU), and then to its various connectivity systems.

A two-way communication with the EFB means that the computed results of various calculations can be fed from the EFB to the FMS and other avionics. It also means the flightcrew can use the EFB to send communications to ANSPs or to airline departments via the external connectivity systems.

ARINC and Satcom Direct have developed applications that emulate ACARS messages for use on EFBs. The EFB can therefore be used to write messages, which are then sent by ACARS. There are several applications for this, including a wide range of AOC transmissions. These could also include communications relating to maintenance data and technical faults from the ETL software hosted on the EFB.

Weather information

One main EFB function is to provide flightcrews with weather information. There are various levels of sophistication for Wx data and information.

Weather information and data used to be provided via printed maps and charts, together with the other information given in the pre-flight briefing; a flight release. "It is a legal requirement under International Civil Aviation Organisation (ICAO) rules for flightcrews to be provided with world area forecast centre (WAFC) reports as a minimum for non-domestic flights," explains David Marks, aviation sales engineer at The Weather Company, an IBM Business. "The WAFC reports are generated by two facilities in the world: the US Weather Service in Washington DC; and the UK Met Office. The WAFC information includes significant weather and wind charts. Domestic flights could use the weather forecasts produced by local flight information regions (FIRs).

"WAFC forecasts are generated at six-hour intervals at midnight, 6am, midday and 6pm universal time. Airlines acquire WAFC forecasts and information via several main providers and distributors, including The Weather Company (previously WSI), Jeppesen, Schneider Electric, Sabre and Lufthansa Systems," says Marks.

The Weather Company uses government data to create the WAFC forecasts, and distribute them to airlines' dispatch and operations departments. The Weather Company also generates its own forecasts, and is also providers additional customer services. The Weather Company is one provider of terminal area forecasts (TAFs), which are weather forecasts for the vicinity of an airport and are updated every few hours; and meterological actual reports (METARs), which are actual observations and are updated every 30 minutes; and significant meteorological information (SIGMET).

Lufthansa Systems, Sabre and Jeppesen are principally flight planning companies, so they receive the WAFC information, which critically includes wind speeds and directions at different altitudes. Through that function they are also able to provide a weather forecasting and distribution service to airlines.

"This WAFC information is used to create maps and charts that show isobars, weather fronts, cloud formations, wind direction and speed, and the position of jetstreams, and temperatures. It also provides information about significant weather," continues Marks. "Crews will therefore be provided with a set of maps for the weather that is forecast to develop on their planned route. The main drawback of this system is that the weather information can be several hours or almost six hours old when a crew has its briefing. The same weather charts and information will be used throughout the flight, so the weather information can age more than 10 hours for the latter part of a long-haul flight."

In addition to the WAFC information, pilots use governmental weather provided by FIRs for departure, destination and alternate airports.

Class 1 EFBs were used as document readers. Electronic WAFC charts, TAFs and METARs, and local area forecasts could be loaded onto the EFB before departure. If the EFB is an iPad, which does not have a USB port, the weather information has to be uploaded wirelessly, so the EFB has to have a wireless connection. The information has to be pre-loaded on the ground, or through the aircraft's on-ground wireless connectivity system. If a device has a USB port, wireless connection is not required.

A limitation of electronic weather information is that it usually has to be viewed on separate pages to the flight path viewed on the EFB screen. It would be preferable for the weather information to be superimposed on the planned flight path. EFB systems displaying weather information as a document reader generally do not yet have this capability.

Honeywell introduced a Weather Information Service EFB application in April 2015 for iOS and Windows platforms. "Weather Information Service has the ability to integrate with an airline's IT system, and provides weather data overlaid on the flight plan on the EFB, providing a view of the weather for the entire planned route of the flight. The user can select the weather layers they wish to display," says Jason Winnink, technical sales director of aerospace services at Honeywell. "If the aircraft has no in-flight connectivity available to the flightcrew in the air, information can be loaded prior to departure. For aircraft that have connectivity, weather can be uplinked to the EFB at any time during the flight. Observational weather information available includes ground radar data, and satellite imagery. This is updated every five to 15 minutes. Forecast information includes clear air turbulence, icing and graphical SIGMETs."

"Airlines can view the flight path on the EFB and the weather chart on a separate device, such as a laptop computer, or on a separate page on the EFB by clicking a button," says Ingo Ludwig, senior project & product manager navigation solutions at Lufthansa Systems. "Superimposing weather charts and information over the flight path is an EFB software development issue, and we expect to have this available by 2017."

Some airlines have increased the functionality of their EFB systems by using the six legacy connectivity systems while the aircraft is in the air, and cellular and WiFi systems when it is on the ground.

New-generation, high-bandwidth flightdeck connectivity systems should improve the functionality of EFBs.

New-generation connectivity

As described, there are several new-generation flightdeck connectivity systems for airlines to consider. These provide varying levels of data transmission rates. They can be broadly divided between those that are permitted to transmit ATS and all other types of flightdeck communications; and systems that can only be approved to transmit AOC, AAC and APC transmissions.

New-generation flightdeck connectivity systems are based on providing an I.P. link, which delivers higher bandwidth than legacy systems.

The two systems that are due to be approved to transmit ATS messages are Inmarsat swiftbroadband (SBB) and Iridium NEXT.

Inmarsat SBB operates via a system of three I4 satellites, which provide almost full global coverage. The I4 satellites operate with L-band transmissions, and provide an I.P. link to the aircraft. The system provides a transmission rate of 432 Kbps. The aircraft has to be fitted with an L-band satcom system for this purpose.

In combination with the satellite link, the SBB system operates by encapsulating ACARS messages generated in the aircraft's CMU/ATSU in I.P. packets. This is necessary because ACARS messages cannot be transmitted via an I.P. link. The encapsulation process is performed by a software function in the SBB satcom avionics modem. This unit is the Aviator S for Safety avionics unit provided by Cobham.

The encapsulated ACARS message is then transmitted by the L-band satcom system to a ground receiver. Once it has been received the packet is opened and the ACARS message is transmitted through the SITA or ARINC ACARS system protocols.

The combined Inmarsat system and Cobham Aviator S for Safety avionics box can distinguish between ATS and non-ATS messages, and give transmission priority to ATS messages. The system can transmit analogue POA and digital ACARS messages at a rate of 432 Kbps. This is higher than via legacy connectivity systems.

The Cobham Aviator S for Safety avionic unit also provides multiple voice channels and an I.P. link for sending non-ATS data. When used this way, it sends data at higher speeds and at a lower cost than ATS ACARS messages over the SBB I.P. link. The SBB system can therefore be used for three types of flightdeck communications.

The SBB system can be configured so that it connects the EFB (for example, an iPad) to the aircraft's external connectivity system independently of its avionic units.

The system therefore provides a connectivity system that allows the EFB to send and receive large quantities of data economically.

The Inmarsat SBB system is already approved for the non-ATS transmissions of AOC, AAC and APC messages.

Clearly AOC transmissions would form the majority of communications, including all possible transmissions to and from the aircraft's ATSU/CMU that relate to health monitoring data and CMU messages, as well as transmissions to and from an EFB. Communications to and from the EFB are likely to increase in frequency and data size as applications

Lufthansa Systems is one of several vendors to provide a system and service that superimposes real-time weather information and data on a planned flightpath on an EFB screen. Significant weather is denoted using colour-coded polygons and symbols.

develop that take advantage of the increased bandwidth of the new connectivity system. These would start with transmissions relating to the ETL that is hosted on the EFB, and possibly some updated weather information.

The second new way of operating the SBB system is transmitting ATS messages. The SBB system has been undergoing trials with Hawaiian Airlines on its trans-Pacific operations and eight of its aircraft since March 2015.

The purpose of the trial is to verify that the system can transmit all types of ATS messages, including CPDLC as part of the FANS process, at speeds and latency required by the authorities for approval.

"The use of the system in the FANS process is demonstrated by Hawaiian in a video on YouTube," says Kim Gram, vice president aeronautical, at Cobham Satcom. "Hawaiian also discusses how it will use the SBB system in the future.

"Hawaiian is also using SBB to take graphical weather data in real time, and to have a constant pilot-flight dispatcher messaging system operational throughout the flight," continues Gram. "This is demonstrated on another YouTube video. The SBB system is mainly being used by Hawaiian for AOC transmissions."

The SBB system has also been fitted to older aircraft for use as an I.P. link for cabin connectivity and AOC ACARS messages. These include EFB communications and other non-ATS transmissions, such as ETL messaging.

Cobham has recently won a contract from Airbus for the SBB system to be a production line fit on the A320 and A330 families from 2018. The alternative to the SBB system will be the Iridium system. A large number of A320 family and A330 family aircraft in the future will therefore have the SBB system for flightdeck communications. "An I.P. system will be used for ATS transmissions on a large number of commercial aircraft over the next few years," says Gram. "Another advantage of the SBB system is that it is smaller, lighter and more compact than the avionics of the Class L-band system. The cost of the SBB equipment is also falling."

Iridium NEXT is a new satcom system operated by Iridium to supersede the Iridium Classic L-band system. Iridium NEXT will be based on new generation satellites, and it will have a high data transmission rate in the region of 1.5 Mega bits per second (Mbps). The system will be able to send ACARS at high rates of transmission using the same encapsulation system as Inmarsat SBB.

The broadband systems available for non-ATS transmissions are Ku- and Ka-band. Ku- and Ka-band high-bandwidth satcom connectivity systems are used to provide cabin services such as internet connection, the streaming of movies from ground-based servers, and live TV.

Ku- and Ka-band transmissions also provide high-bandwidth flightdeck connectivity systems that can be used for AOC transmissions in particular.

First-generation Ku-band systems have data transmission rates of 1-2Mbps, while later generation HTS Ku-band satcom constellations and networks provide data transmission rates of up to 30Mbps. Inmarsat's Ka-band Global Xpress (GX) system has a transmission rate of 12Mbps.

There has always been a major concern that the K-band connectivity system being used to supply the passenger cabin should not also supply the flightdeck, because of security risks. These risks can be overcome by splitting the Ku- or Ka-band signal into two or three channels, one of which is fed to the flightdeck to provide connectivity. Airlines must gain regulatory authorities' approval to do this by providing operational proof that the system works in parallel with legacy flightdeck connectivity systems.

The AOC transmissions that a Ku- or Ka-band connectivity system will allow are high volume EFB communications.

"Our 777 fleet is equipped with a Ku-band system supplied by Panasonic for the passenger cabin, and the signal reaches the flightdeck," says Rick Allen, senior vice president of operations at Etihad Airways. "Boeing is now working to certify the system to allow operators to use the signal on the flightdeck, under certain conditions, and this would provide the EFB with access to the internet."

Besides these specific satcom systems, aircraft can also be equipped with a variety of wireless on-ground connectivity system that can be upgraded to create a wireless access point (WAP) on the flightdeck. "The Teledyne wQAR box is installed on our A320 and A330 fleets, and a WAP on the flightdeck can be used to transmit avionics parameters to the EFB as a one-way link from the avionics to the EFB," says Allen. The same equipment from Teledyne can also be connected to the satcom systems. This set-up means the EFB can be fed with avionics data.

"High-speed connectivity on the flightdeck is also being developed across the whole fleet of more than 100 aircraft," continues Allen. "The original equipment manufacturers (OEMs) are starting to offer high-speed connectivity systems that can be used with COTS devices and EFBs on the flightdeck, and so we expect to have high bandwidth systems for our 787 and new A350 fleets."

Flightdeck applications

The applications of the new-generation flightdeck connectivity systems are likely to improve on existing uses of legacy systems, including better and real-time weather information, better

Air Canada is trialling Gogo's 2Ku-and system with the aim of using it for three channels, one of which will provide high bandwidth connectivity for the flightdeck. Air Canada plans to use The Weather Company's Pilotbrief Optima system with the Ku-band connection.

maintenance and health monitoring data, and higher speed ETL operations.

Several other developments are likely to take place, and these will require the high bandwidth of new-generation connectivity systems. These include new EFB applications and live visual transmissions from the flightdeck, as well as a constant AOC link between the flightdeck and ground departments.

Air Canada is an airline that is updating its fleet and considering how to use a broadband flightdeck connectivity system. "The connectivity systems on the fleet are evolving," says Steve Bogie, senior director of operations information systems at Air Canada. "We have an on-ground WiFi system for the flightdeck, and the Gogo air-to-ground (ATG) system for the passenger cabin for our narrowbody fleet. The Gogo ATG system is low bandwidth and has only been installed for one year. We have four networks on the aircraft, for the passenger cabin, for the flight attendants, for the flightdeck, and for WiFi system maintenance. The advantages are that it provides us with a high bandwidth cabin system, and then with small increments in cost it provides us with a system for flight attendants and the flightdeck.

"We will be fitting our widebody, international fleet with high-bandwidth satcom, and will use Gogo's 2Ku-band system," continues Bogie. "This will provide the same four networks on the aircraft as on the narrowbodies. It is easiest to regard the 2Ku-band system as three separate channels."

Bogie explains that Air Canada does not yet have approval to use the 2Ku-band system in split channels, but it is trialling the system on a narrowbody aircraft for AOC flightdeck communications. "We are fitting the fleet in anticipation of being able to use the system for AOC communications in the short term," says Bogie. "This will be for real-time weather information, especially turbulence and changing weather patterns. We will also use it for flight plan updates and crewing information. We are expecting there to be more developments in EFB functionality and applications."

Improved weather

There are several ways of improving weather information by using a high broadband connectivity system. The first is being able to provide the latest of the six-hourly WAFC forecasts on the EFB in an electronic form. Other improvements include having access to real-time severe and significant weather on the EFB, and sending all types of graphical weather information to the EFB.

The ability to send updated WAFC information to the EFB will be beneficial to long- and ultra-long-haul flights. Previously, WAFC updates could be sent up to three times just before and during long- and ultra-long-haul flights.

A second development is the ability to superimpose several layers of graphical weather information on the flightpath displayed on the EFB. Graphical weather information includes: rainfall radar images, weather fronts, isobars, cloud formations, the position of jetstreams, wind direction and strength, warning areas, lightning, storms, turbulence and icing. The big advantage of graphical weather is that it is geo-referenced on a chart.

The Weather Company has had a service for several years for corporate jets operating over the US where weather data are updated every five minutes. The weather information is sent from the ground source to a satellite, and then beamed to the aircraft and viewed on its EFB. This provides information relating to rainfall, wind speeds and directions, temperatures, and severe weather.

Lufthansa Systems expects to have the ability to superimpose graphical weather with its EFB products in 2017. This relies on having the weather source, being able to integrate the information for visualisation needs, and being able to get the data to the EFB.

Two types of weather information can be superimposed on an EFB flight path.

The first type is the traditional WAFC information. "We are still evaluating the size of this transmission for overlaying WAFC information on the flightpath screen on the EFB," says Ludwig. "The size of the data package also depends on the weather phenomena. Data on the presence of tropical storms will depend on their severity at different altitudes."

SITAONAIR has an EFB weather service that supports an application referred to as the electronic weather awareness system (eWAS). eWAS was developed in partnership with GTD Systems of Barcelona. Toby Tucker, portfolio director innovation at SITAONAIR explains that the system can first be updated on the ground using cellular or WiFi connectivity systems that the EFB device will have."When in the air the system can use these data, updated on the ground, to display different forecast layers that include turbulence, cloud tops, clear air turbulence (CAT), icing, and SIGMET," says Tucker. "These forecast layers can include many hours of flying time. The system works by moving to the relevant forecast period as the flight progresses. The pilot can drag a time bar to visualise the weather further into the flight. This is at any time pre-flight or while in flight, since the forecast layers, shown in an overhead and flight level profile view, will therefore move in relation to the time bar slider. Significant weather layers have a 24-hour validity, made up of eight lots of three-hour forecast periods. The system is comprehensive for all stages of flight, so it can be used pre-flight and in the air. For in-flight connectivity, the system works with legacy ACARS and I.P. broadband satcom systems. I.P. connectivity can receive data over oceanic areas, whereas a VHF ACARS link will drop off over water. The application uses multiple sources of weather data. These include Schneider Electric, The Weather Co, The UK Met Office, and Meteo France to present a comprehensive view of significant weather.

"If the EFB device is connected, the pilot can receive new forecast layers and NOWCAST observations in eWAS from SITAONAIR's EFB Weather ground server via a datalink, such as VHF or satcom," continues Tucker. "This requires the EFB to be linked to the aircraft's avionics via an AID. The EFB can also receive information via a hidden WiFi signal from the passenger cabin satcom IP link. The AID is not required, so a SITAONAIR hardware device called ONAIR Plug manages the authentications of the devices and access to the link. The I.P. link via the cabin can therefore be used to acquire the updated weather layer information, which typically has a lower data cost compared to flightdeck connectivity systems, plus it keeps the flightdeck comms channel clear for CPDLC/ATS traffic. "

EFB Weather can also update eWAS to have METARs and TAFs updated in-flight, and SITAONAIR provides this service. These updates can already be received by ACARS, but an airline would benefit from consolidating the data on the FMS, but also now on eWAS on the EFB.

The second type of weather information that can be used is the data that is frequently generated and transmitted in real time to the aircraft via a legacy or new-generation high bandwidth connectivity system. Lufthansa Systems plans to introduce electronic weather information on the EFB from the providers of the standard weather information that includes Lufthansa Systems, The Weather Company and Schneider Electric.

"Our intention is to view real-time graphical weather as overlaid information on EFBs," says Ludwig. "These weather updates are published about once every 20 minutes, so they are not completely in real time. The size of data transmission is still being evaluated."

SITAONAIR's eWAS system also uses real-time or frequently updated weather information.

The Weather Company is another provider of frequently updated electronic weather information for superimposing on the flightpaths displayed on the EFB. "Our main product for this is referred to as Pilotbrief Optima," says Matt Taylor, director of business development for aviation at The Weather Company. "The system updates the original weather information uploaded to the EFB during pre-departure preparation. The information is updated frequently, since it comes from weather radars and multiple sources. We collate the weather radar information, which is updated at intervals of about five minutes. The information is then available on-demand to airlines and aircraft using the service.

"We provide a variety of aviation weather information to our own applications, as well as through partners. The information can be displayed graphically on the EFB using its embedded geolocation properties," says Taylor. "An example is our specialised flight level significant hazard forecasts. These are displayed as coloured areas indicating the geographical position of the particular weather phenomena. While the flight is en route, the hazard areas can be used to inform requests for changes in routing and altitude to provide a smoother, more efficient, and safer flight. Additionally, hazards that are not well detected by the aircraft weather radar or visually by the pilot, like clear air turbulence, can be identified and the impact mitigated ahead of occurrence. These specialized forecasts that we call WSI SIGMETs and FPGs includes convection, turbulence, icing, volcanic ash, ozone, dust and even nuclear fallout. The type of weather is denoted by the colour of the areas or other commonly recognized aviation icons. In our products, blue denotes turbulence, red denotes convection, and green denotes icing. There is also additional symbology to provide extra information like pilot reports (PIREP)." More traditional weather types, including weather fronts, jet streams, wind speeds and wind directions, are also available with more frequent updates.

"The information is presented as high-resolution images on the EFB screen, and can be as detailed as one half of a kilometre for each pixel," says Taylor. "There are limits in terms of flightdeck connectivity systems, however. Affordability is the main issue for airlines. While text information is just a matter of kilobits, visual information will be an average of hundreds of kilobits or megabits in total for a flight.

"The need for this service is to have frequent weather updates in global areas where data is otherwise sparse and when the weather is changing rapidly," continues Taylor. "Examples are convective areas such as the equatorial latitudes such as the mid-Atlantic, or India and The Bay of Bengal. Pilots need something better than just the aircraft's weather radar for improved strategic awareness and action. Pilotbrief Optima provides detailed graphical weather information over a long distances."

Pilotbrief Optima is in use with airlines around the world, as well as corporate jet operators.

Another product provided by The Weather Company is Total Turbulence. "This a combination of patented technology software installed on the aircraft's avionics to detect and report turbulence encounters, as well as the ground systems to process and alert to the hazards back to our users," says Taylor. "The system also routinely reports to our ground system at 20-minute intervals. This can identify areas where

Thomas Cook has its A330, 767, 757 and A321 fleet fitted with Iridium Classic. It operates an ETL system, which only has on-ground connectivity. It is possible that Thomas Cook will upgrade to Iridium NEXT for use as a high bandwidth connectivity system. This could be used for high-priority messages from the flightdeck.

turbulence was forecasted but is not actually occurring. The information is collated and is ultimately passed into the Pilotbrief Optima system and airline ground operations control systems like The Weather Company's Fusion flight tracking product. Therefore, a pilot using the Pilotbrief Optima system in the air will receive detailed and objective information in real time about turbulence encounters in the vicinity that the aircraft is flying. These turbulence reports are generally available within a minute of the report generation, although this depends on the robustness of the data link connectivity."

Air Canada is trialling the system as part of its trial on a narrowbody for the 2Ku-band system split into three channels, and the use of the Pilotbrief Optima system. "The system requires a critical mass of airlines to use the systems to get enough turbulence data," says Bogie. "It is already in use with United and American Airlines."

Improved maintenance

High-bandwidth connectivity systems for the flightdeck may improve the scope of using an ETL. ETLs have replaced paper technical logs in many cases, but information is usually downloaded from the ETL when the aircraft is on the ground rather than being transmitted in the air, even though one of the main features of the ETL is transmitting fault and maintenance data in real time. This is to provide maintenance control and line maintenance departments information as soon as possible.

"Most ETL software developers have been trying to compress and minimise the lumps of data that have been sent to and from the ETL," says Paul Boyd, managing director at Conduce. "This to make them compatible with the legacy connectivity systems for airlines that want to send information in real time. Despite this, we have never implemented real-time transmissions from the ETL, because airlines have not asked for it.

"The main reason for this is that airlines are unable to use the information that is sent from the aircraft," continues Boyd. "Another reason is the high cost of sending transmissions with legacy connectivity systems. If genuine data are sent from the aircraft then a secure link and tight protocols are needed."

Boyd adds that Conduce does not yet have an airline with the high data transmission rate connectivity systems in place. Thomas Cook is one airline using Conduce's ETL system. It operates a fleet of A330s, 767s and 757s with Iridium Classic satcom system, allowing it to conduct FANS long-haul operations in many regions of the world. It also operates A321s, and was the lead airline to operate the Airbus line fit Iridium Classic system. "We currently operate the ETL as an on-ground system, rather than transmitting while in the air," says Paul Stephenson, operational performance manager at Thomas Cook Group Airlines. "The ETL is hosted on a Panasonic Toughpad, and has an in-built 4G system and SIM card. This connects to the cellular network when the aircraft is on the ground. We also operate an EFB on an installed Hewlett Packard tablet, which also only transmits when the aircraft is on the ground. These are separate because pilots and line mechanics want to use the devices at the same time. The two devices will later be connected to an on-board server when they are installed on the aircraft.

"We already have a legacy satcom system, but this is only used for sending ACARS messages," adds Stephenson. "There is a possibility that we could use Iridium NEXT as a high-bandwidth connectivity system for high-priority messages from the flightdeck, as well as for flight attendants to conduct credit card transactions. The high priority messages would be operational AOC messages and transmissions to and from the ETL and EFB. We will probably push AOC communications in a new system from the EFB via an AID to the aircraft's CMU/ATSU when in the air. We expect Iridium NEXT to have a high data transmission rate, but the only issue is that the satellites are due to be launched in late 2017 and early 2018."

Cameron Hood, chief executive officer at Nvable, alludes as to why many airlines are still not sending data in flight from ETL systems. "Airline maintenance departments still need to have the organisation and process to react to, and use, the information that is sent from the ETL. Airlines are not always certain that connectivity links to the ground are available when they are needed.

"This will change if there is high-bandwidth flightdeck connectivity that airlines can be sure will keep them connected to the aircraft 99% of the time," continues Hood.

"The presence of a reliable high-bandwidth flightdeck connectivity system means that an airline can better plan the organisation of its operations, maintenance control and line maintenance," adds Hood. "Having such a connectivity system makes this organisation completely different to the traditional way of doing things without a constant connection with the aircraft. Most airlines operate in a reactionary way. As a basic example, the line maintenance department starts planning a response when component and system failures take place."

Hood makes the point that a high bandwidth connectivity system will also allow augmented reality. Augmented reality is a system whereby a user views a real piece of hardware, such as an aircraft component or the flightdeck, and additional graphical information and images are overlaid on the view. This assists the user in their task. Such a technique is now being developed for aircraft maintenance, but the use of augmented reality in aircraft operations is unlikely in the short to medium term.

"Systems such as the ETL will now be designed on the assumption that aircraft have a constant and high bandwidth capacity," adds Hood. "An example of this will be the ability to include a video channel, which could enable contact with line maintenance or operations departments. This may assist pilots dealing with technical or operational problems, who would then not have to communicate with the ground via ACARS messages. The overall long-term implications are that airlines would not have to place so many skilled staff at so many locations on their route networks. This would clearly lead to long-term cost savings."

EFB applications

In recent years several EFB applications requiring a high-bandwidth flightdeck connectivity system have come to the market. Some of these are fuel-saving software systems, and operate by optimising one of several phases of a flight profile. These are generally based on using real-time weather and wind data.

Honeywell has two services to help crews optimise vertical flight levels. Both operate by assisting the flight crew to choose the optimum altitude based on winds and temperature aloft. Combining this with the actual weight of the aircraft at departure, the vertical profile can be optimised over the vertical profile calculated for the flight plan that is generated prior to the flight.

The first of Honeywell's services uses updated wind data sent via ACARS to the FMS during flight. The software in the FMS recommends the optimum flight level (FL) and the descent profile to optimise fuel burn for the portion of the flight. Flightcrew can then load updated wind forecasts into the FMS during flight.

The second service that Honeywell is trialling with airlines, and that will soon be released to the market, is a graphical vertical optimisation that runs on an iOS or Windows EFB. While this application performs the same function as loading wind data to the FMS via ACARS, there are added benefits in terms of the EFB's processing power and the intuitive graphical interface provided to the flightcrew. Recommended step climbs are displayed graphically to the flightcrew, with optimisation algorithms continuously running and updating as new optimisation recommendations become available. The application will be able to run by receiving information directly from the FMS via an AID, or pilots can periodically enter flight parameters manually.

In addition to Honeywell's fuel optimisation systems, there is a range of other fuel optimising systems that operate on an in-flight basis. German software provider PACE has a system called Pacelab Flight Profile Optimiser (FPO), and this is used on an EFB. It uses real-time operational data, and optimises the vertical profile of a flight. The vertical profile of the planned flight is shown on an EFB screen. The system optimises the climb, cruise and descent phases of the flight by using the fuel load and the aircraft's centre of gravity.

The system also uses live weather data relating to en-route wind speeds and directions which are regularly updated during flight. The system thereby gives the crew a visual display of the optimised vertical profile.

There are several other possible uses of a high bandwidth connectivity system with respect to an EFB. William Baumgarten, business development director at UTC Aerospace Systems explains that one particular type of new EFB application would be a live or occasional video surveillance. "The ability to send video surveillance to the ground will be particularly beneficial with respect to maintenance problems," says Baumgarten.

"The next best application for the EFB is not really the main issue of high-speed connectivity systems. High-speed connectivity to and from the flightdeck will allow a constant contact between the aircraft and various airline departments," says Michael Bryan, chief executive officer at Closed Loop Consulting. "This will provide improvements on a broader operational level. This includes bringing the EFB ecosystem and the aircraft into the Internet of Things (IoT) and the e-Enabled airline. It will also help provide further overall columniation between aircraft and the ANSPs." AC