Live weather updates can enhance the safety and efficiency of a flight. This capability has been made achievable by the emergence of high-performance connectivity systems, while applications are now designed specifically for in-flight usage. Live, or regular, weather updates are now relatively easy to obtain for connected airlines.

Applications to provide EFB systems with live weather data and information

Electronic flight bags (EFBs) are performing an increasing number of functions for flight crews via new applications. This mounting sophistication has led to the development of new-generation connectivity systems that can support the transmission of time-sensitive data due to their increased bandwidth. Examples of new generation connectivity systems include: Gogo's 2ku, Swift Broadband (SBB) and Swift Broadband-Safety (SB-S); Ku-band; SmartSky; and Iridium NEXT.

Airlines are beginning to realise that big data can be used to enhance safety practices and optimise fuel and cost efficiencies. Examples include provision of live, real-time weather updates to flight crews in the cockpit, and graphical weather reports. "Live weather updates have been made possible by the availability of mass data," says Patrick Wipplinger, chief product owner Lido/Navigation at Lufthansa Systems. "Meanwhile, graphical weather reports have become an increasing requirement of operators because they provide flight crews with an overall picture of the region in which they are flying. On-board weather radar detects weather patterns ahead of the aircraft, but can't depict weather hazards behind each other. The picture provided by a graphical weather report offers pilots a strategic view for circumnavigating weather hazards. New-generation connectivity has allowed these reports to enter mainstream operational use."

Transmission of weather data is an element of airline operational communications (AOC). AOC comprises most of the high volume of data communications transmitted from the cockpit. "Live weather updates improve the safety and efficiency of flights by providing pilots with real-time weather reports," summarises Philippe Lievin, director of connected aircraft marketing for Rockwell Collins. "A typical example developed by Rockwell Collins is the AOC On Tablet Application. Weather data can be 'transferred' to an AOC message or feed automatically into a weather report in the application."

The other main type of flightdeck communications is safety-related air traffic service (ATS) messages *(see Flight deck connectivity systems vendors survey, Aircraft Commerce, April/May 2015, page 33)*, which require a secure connectivity channel such as SB-S. It is important, however, to provide a secure channel for weather.

"Weather data is AOC data," explains Matthew de Ris, manager of aviation programmes & strategic partnerships at Panasonic Avionics. "While a secure channel is not legally required, such as for ATS messages, weather data still needs a certain level of security. It therefore needs to be handled via a means secured from typical cabin data (such as in-flight entertainment (IFE)) to avoid signal disruption." de Ris notes that potentially urgent messages, such as weather alerts and extended-range twin-engine operational performance standards (ETOPs) updates, can be received in the cockpit via a light connection, such as the aircraft communications addressing and reporting system (ACARS). "The focus of live and graphical weather data is, therefore, to increase situational awareness and enable the flight crew to make better informed decisions, rather than to make direct safety improvements," he says. "ATS communications are already met by standard frequency protected communication channels."

It has taken time for the industry to build confidence in electronic processes, and in particular the security and reliability of in-flight data connections. This confidence has been built on early EFB usage, and the greater presence of connectivity in the cabin via inflight communication (IFC) systems. Passengers and crew members now expect more communication options available in-flight from on-board cellular and WiFi systems.

Transferring this usage into more sophisticated cockpit intelligence, such as access to live or graphical weather, is now relatively simple because airlines are increasingly connected. "The capability is developing quickly thanks to the evolution in connectivity options available," adds Wipplinger. "Weather has been a big topic within Big Data Analytics, since it can save airlines fuel costs and enhance passenger comfort."

Benefits of live weather

Weather has the potential to affect more than just passenger experience. Optimising the use of sophisticated weather data, in particular live weather, can, therefore, enhance many areas of airline operations. Primary considerations extend to safety, operational reliability, and cost efficiencies. "Directly or indirectly, weather affects almost every facet of a flight," says Toby Tucker, portfolio director of cockpit and cabin crew applications at SITAONAIR.

"Fuel is one of the largest operating costs an airline has, and weather conditions are a key factor in deciding how much fuel is loaded onto each flight," continues Tucker. "Any additional

Real-time weather data can enhance and benefit most aspects of flight operation. Accurate live and 'nowcast' weather data can be used by flight crew to plan ahead and avoid potential weather-related hazards inflight.

weather forecast data helps ensure these decisions are as accurate and cost-effective as possible. Additional fuel savings may result from flight crew having longer-range data to help them plan and execute the most time- and cost-efficient weather avoidance strategy during a flight."

Tucker adds that once in-flight, passenger (and flight crew) comfort and safety are directly improved by better weather data. "Flight crew cannot always avoid turbulence, but it improves their ability to plan for, and react to, adverse weather when it is unavoidable. Flight crew could, for instance, relay potentially turbulent time periods to their cabin services team, to avoid food and hot drink being served at those points," he says. "We also believe airlines will benefit from time and cost reductions in planned (and unplanned) aircraft and engine maintenance by using accurate and real-time forecasts. Improvements in weather data help aircraft spend less time in turbulent conditions, and expose engines to hazardous contaminants - that may degrade engine performance - for shorter periods."

EFB functions

When building a case for connectivity, it is worth considering what the operator is already using connectivity for. It may have IFE available to customers, in-flight WiFi communications, or just ground-to-air capabilities for the use of an EFB.

The extent to which connectivity is used, therefore, varies, and will in turn affect what type of connectivity and system solutions operators will use to implement regular or real-time weather updates. "There are multiple use cases when incorporating live weather," says Lievin. "The main examples are: AOC on tablet (datalink services reallocated on portable electronic devices (PEDs) vs. legacy ACARS routers with interaction from the multi-function control display unit (MCDU)); graphical weather applications; and data synchronisation services with the airline's ground network. These are all now achievable via the EFB."

"The main EFB applications that require an external connection are live weather, technical logbook, and flight following applications," adds Anaelle le Mentec, product owner of Globe at Thales Avionics. "Graphical weather applications benefit from live updates, which can be crucial for long-haul flights; or for Nowcast (short-range weather forecasting) predictions that have a very short validity range. Technical logbook applications can send information on the defect entered by pilots during flight to enable maintenance operators to anticipate their treatment. Maintenance operators can prepare repair operations too, which can make resuming normal operations in the event of disruption much faster."

EFBs today come in two main formats: installed and uninstalled. Rockwell Collins provides live weather from uninstalled PEDs connected to a connected aircraft interface device (C-AID). "This is via a WiFi service in the cockpit," adds Lievin.

AIDs provide EFBs with a connection to the aircraft's avionics and its operating parameters, and so can enhance the information provided by the EFBs. "AIDs connect an uninstalled EFB to the aircraft databus," explains Wipplinger. "Operators will need this hardware to obtain weather updates specific to the aircraft's position, for example."

"An AID can provide secure access to the aircraft's communication systems for in-flight updates of applications hosted on the EFB," adds Tucker. "By connecting SITAONAIR's EFB weather awareness solution eWAS in-flight, the pilot can more accurately track areas of interest, such as active thunderstorm cells that are changing in intensity and location.

"EFB applications, such as the charting application, also benefit from a connection to the aircraft's system via an AID," says Tucker. "This provides own ship position to the charting app to show location of the aircraft, according to the aircraft's own GPS system. Other information on the aircraft's fuel, engine and sensor data can also be fed through the AID by connecting the 429/717 databuses, and feeding these to the EFB apps. This includes the EFB's navlog for auto-population of the fuel and time at each waypoint, or for capturing and sending on flight operational quality assurance (FOQA) / maintenance operational quality assurance (MOQA) data on the ground."

"Moving map and performance calculations require connection to an aircraft's external connectivity systems," says de Ris. "Aircraft parameters are made visible to the EFB via these systems. An AID allows the crew to look over time to see how the weather is forecast relative to aircraft position. An AID can also update position and estimated time of arrival (ETA) within the relevant applications, which could be made available to ground operations via two-way connection."

Live weather can be provided to both installed and portable EFBs, explains Tucker. "EFBs can use modern AID systems that give secure, controlled access to the aircraft communication systems. If provided by SITAONAIR, the AID needs a software layer called AIRCOM® Connect, to allow the secure use of these communications links, which also require traffic prioritisation and data compression to work well.

"Once loaded with AIRCOM® Connect, the AID safely uses the cockpit communication links to provide updates to all types of portable EFBs," continues

Tucker. "This is either by wiring an ethernet connection to the device and/or EFB mounting, or by the AID providing a secure hidden WiFi access point. Installed EFBs can also benefit from the same update method."

"A Class 1 EFB can also receive live weather updates through the WiFi network of a cabin SATCOM," adds le Mentec. "If an AID is equipped with a wireless access point (WAP), then ACARS or cabin SATCOM can also be used. Class 2 EFBs can receive updates in the same way as a Class 1 EFB. They can also be wired to an AID, in which case no WAP is required for updates through ACARS or cockpit SATCOM."

Airlines incorporating EFBs and connectivity solutions into the cockpit also need to consider whether a one- or two-way data connection is required for the EFB. For instance, receiving automatic updates from ground-to-air for safety related alerts will usually require just ground-to-air connectivity. If flight crew want to request information of the EFB, however, or customise route plans based on weather information received, for example, then a two-way connection is needed. "The requirement for two-way data connection depends on the update process," says le Mentec. "Update requests triggered by pilots require a two-way data connection, whereas a one-way data connection is sufficient for updates pushed by the ground."

"To enable truly live weather, or customised updates, the operator needs both aircraft-to-ground and ground-to-aircraft broadband connectivity," continues Lievin. "This is because the EFB is selective, and will request the weather on a specific region/area relative to the route (an aircraft-to-ground request). The provider for that operator will send the weather data back to the aircraft as requested (ground-to-aircraft communication)."

"If the EFB system in question does not need flight-crew-requested data, then a two-way connection is generally not required for live weather, as is the case with the US FIS-B system" says de Ris. "Feature richness, alternates planning or re-planning, and last-minute changes, however, would benefit from the two-way connection. The pilot could request a weather update, for example, and then plan the remainder of the journey or approach accordingly. For international trips, a two-way connection is recommended due to the length of these flights and the potential changes that may occur inflight."

"SITAONAIR's eWAS application requires ACARS or IP broadband connectivity inflight, and 3G/4G or WiFi on the ground, to deliver real-time updates," says Tucker. "A two-way data connection is preferred and available inflight using AID software, such as AIRCOM® Connect. This is because the eWAS application has a mode for the pilot to manually request updates within the client application, for example, to refresh observation data for a specific area to receive the latest data for an intense storm or area of severe turbulence the pilot is monitoring. Automatic updates are also catered for.

"For an airline to adopt eWAS, it needs: an EFB device (windows tablets or iPads are both supported); ACARS or internet protocol (IP) broadband connectivity inflight with SITAONAIR's AIRCOM® Connect software to control the correct way to use the in-flight available cockpit communications; and 3G/4G or WiFi on the ground for real-time updates. An AID is also required, or an EFB that is connected to the cabin broadband link (On-Air Plug or certification required)," adds Tucker.

It appears, therefore, that AID usage depends on what the operator requires. If the operator wants position, for example in relation to weather on a moving map, and the EFB is not integrated or installed, then an AID is needed.

AVIOBOOK's Globe module can be customised by airlines in accordance with their weather update policies. Airlines can elect to allow on-demand weather updates, or manage these automatically.

If, however, the operator just wants to prompt for real-time weather updates, then that depends on the iPad, weather application and its connectivity to a broadband channel that can communicate with a ground server. An AID is not necessarily required in this instance if the airline is authorised to use a cabin link for such updates. An AID that can map the position of the aircraft relative to a detailed, graphical weather update may, however, improve the report's accuracy and sophistication. Some applications also need an AID for in-flight updates. "An AID is required to update the eWAS application in flight (using cockpit communications), since it provides the secure physical access to the aircraft's available cockpit communications," says Tucker.

"When the weather uplink function is integrated into the aircraft's avionics suite, displaying maps on the avionics displays (mainly present on regional aircraft), then an AID is not required. This is because the avionics already provide avionics parameters to the weather app (such as current position of the aircraft, altitude and heading)," says Lievin. "For legacy aircraft, an AID is, most of the time, required to get safe access to both the avionics data and the communication channels."

"While AIDs can certainly enhance weather capabilities, such as the provision of graphical weather on a moving route map, they need additional installation, certification and supplemental type certification (STC)," says TJ Horsager, director of product management for connected aircraft services at Gogo Commercial Aviation. "The Federal Aviation Administration (FAA) and European Aviation Safety Agency (EASA) are also allowing airlines, on a case-by-case basis, to trial and adopt the use of the internal global positioning system (GPS) available on iPad and tablet devices to provide the same location details. This provides a cheaper non-installed alternative for those looking to achieve weather relative to aircraft position."

Connectivity & transmission

Broadly speaking, the most popular high-performance connectivity systems in use today are Iridium, 2Ku, and S-BB systems. Transmissions are sent by internet protocol (IP) and transmission control protocol (TCP).

"IP and TCP data is inherently two-way," adds Horsager. "Two-way connectivity is to associated ground weather servers. Modern applications are founded on TCP/IP, so two-way connectivity is adopted by most operators."

"Two key limitations have prevented widespread development of live weather and graphical weather overlays," says Ravneet Marwaha, offering manager for aviation, The Weather Company, an IBM Business. "The first has been lack of, or poor, connectivity on the flight deck, and the second has been the high cost of achieving connectivity on the flight deck. There are no security concerns with the transmission of weather data because it is not an ATS message."

These new-generation channels allow graphical weather to be used in-flight. "The required weather data, mandatory for commercial flight is WAFC, METARS and TAFS, and these can be transmitted through ACARS," says de Ris. "New-generation connectivity systems have therefore not been initially adopted to allow the distribution of this core data, but to enhance the richness of the weather information that can be received on the flight deck. Graphical weather allows richness of detail, such as convective activity; gradations of severity that would not otherwise be available such as those found in newer turbulence forecasts and volcanic dispersion areas; and 3-D and 4-D manipulation allowing the pilots to view the information in new and previously unused ways. This is where high transmission rates are required, depending on the circumstances in which flight crew want access to this information. Combining this level of detail with real-time updates, if required via pilot request, is what needs the new generation connectivity. Additionally, for 4-D based displays, each slice of time needs to have the same richness of information for a truly live weather forecast."

"ACARS connectivity is enough to support retrieval of most of the weather elements," adds Lievin. "Most of the existing implementations do not require transfer of 'graphical' elements, but only a set of coordinates with associated attributes describing the weather element. These are referred to as 'polygons'."

According to Tucker, data with frequent update cycles benefits hugely from new-generation connectivity systems. "Historically, weather information is 4-6 hours (or more) 'old' by the time an aircraft departs, but improved connectivity now reduces this delay to minutes rather than hours," he adds. "Older-generation communications can upload light textual weather information (such as METAR and TAF) in flight," says le Mentec. "New-generation connectivity systems can supply EFBs with data on turbulence, thunderstorms, icing, lightning, volcanic ash, jetstream presence and position, temperature, winds, surface visibility, surface winds and more. Different weather providers offer fairly accurate products and frequent updates."

"Typically, Aeronautical Information

Regulation and Control (AIRAC) data can be directly downloaded to the EFB," explains Lievin. "Those AIRAC updates require about 3 MB to download. It is difficult to transfer this data through the legacy VHF/HF communication means."

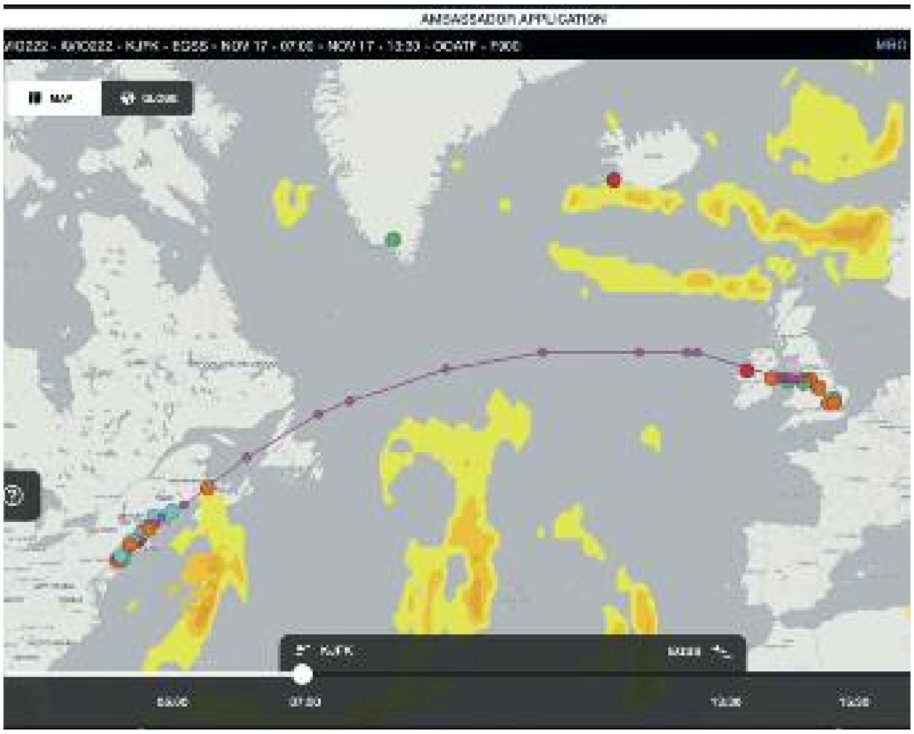
Lievin explains that WAFCs can be uploaded automatically in flight. Transmission rates are again relatively small. "Contrary to a common understanding, the background maps are not downloaded in the aircraft, but are already preloaded," he says. "Only the 'dynamic' weather elements, such as cumulonimbus cloud (CB), turbulence and winds are uploaded from the ground weather data provider. These are displayed as a set of polygons with associated attributes. As a result, it only requires a few kilobytes to display an accurate picture of the surrounding weather relative to an aircraft's position," continues Lievin.

As Marwaha explains, additional weather data can be supplied to an EFB by using new-generation connectivity systems as opposed to VHF/HF or SATCOM. "It enables the near real-time observations of weather phenomena, such as cloud tops and lightning, the latest information on active Significant Meteorological Information (SIGMETS), TAFS and METARS and more frequent updates to forecasts, where available," he says. The Weather Company can provide graphical layers with update intervals of 5-15 minutes via its WSI PilotBrief Optima application. "Depending on the connectivity state and quality, near real-time weather data can be available on the aircraft, including observations for cloud tops, lightning and turbulence events (as reported by other aircraft in the regional vicinity)."

Panasonic weather solutions (PWS) is currently focusing on achieving the greatest level of accuracy in its forecasted, rather than live, weather. For this, de Ris explains that Iridium Certus connectivity is perfectly suited to providing high-level weather forecasts and updates. "Iridium Certus will provide a minimum of 88kb/s air-to-ground connectivity, which is enough to achieve graphical weather and real-time updates. With a properly designed automated system, updates can be delivered in the background in such a manner that its data use is not onerous or impacted by delay issues rather than by specific pilot-request," says de Ris. "Graphical weather capability would not be subject to urgent request activity, so this transmission rate is more than adequate. If a pilot needs to request real-time high-volume updates in-flight, however, then the transmission rate needs to be higher and a broadband connection is more suitable. This depends on the selected EFB application system. Iridium connectivity is fine for convective and turbulence forecasts, because the pilot will not be making request/reply actions," continues de Ris.

"As weather objects are transmitted compactly, and never as images, data can be easily compressed and optimised," says Tucker. "WiFi and cellular or SATCOM broadband connectivity (for example, Inmarsat SBB, and GX) are good candidates because they transmit at rates of mb/s links). SITAONAIR has also optimised the solution to work on ACARS (kb/s), because we recognise that not all aircraft are equipped with broadband IP SATCOM, and in this case only observational data for a specific area of interest would be updated inflight to limit the size of data exchanged."

"Live weather is a tiny fraction of data that new-generation broadband systems are capable of providing," adds Horsager. "The demands on an operator's software and connectivity systems are not nearly as extensive as the needs of a cabin



Pilots using Globe can filter weather information, such as turbulence, icing and thunderstorms, depending on the data needed for the region of operation.

full of passengers, all requiring varying levels of data connection from a network. Live weather is, therefore, relatively easy to obtain."

Transmission rates required for live weather and graphical overlays, in addition to the frequency required of weather updates, depend on the region of aircraft operation, Wipplinger explains. "For instance, for flight crew operating close to the Intertropical Convergence Zone (ITCZ) near the equator, where weather hazards such as thunderstorms are more common, updates could be required every five minutes or so, whereas European operations do not," he says. "This affects the transmission capability an airline needs."

While graphical weather overlays, positioned on the flight plan, are now in operational use, Tucker also adds that SITAONAIR can provide overlays that incorporate regularly updated weather data. "We urge caution with the term 'real-time' data when it comes to communication, because there is always a delay of some sort between the actual source of data (be it satellite, ground radar or other instrumentation) and the end-user," he says. "That said, eWAS has multiple layers of near real-time data, some of which is refreshed as often as every 10 minutes if required."

Achieving live weather updates can be complex, in that there is now a variety of different solutions and technologies available for operators, depending on their weather needs. "Broadband connectivity offers greater feature richness, but ACARS can also be used for basic weather updates, although the throughput is low and, barring some notable exceptions, completely text based," explains de Ris. "When graphical weather is combined, higher throughput is needed to allow richness of detail and reliable frequent updates."

Weather applications

Gogo can provide live weather data to airlines, and supports any weather app its customers prefers to use. Its client base includes Japan Airlines (JAL), Virgin Atlantic and Air France. "More than 50% of our customers have already implemented, trialled or investigated gaining live weather capability," says Horsager. "Most of these customers also operate aircraft with cabin connectivity, such as in-flight WiFi. As confidence in the reliability and strength of this connectivity has accumulated from its passenger usage, these airlines now want to move this data communications capability to the cockpit."

The Weather Company has graphical weather in operational use via its WSI Pilotbrief Optima Application, which comprises part of a customer's EFB application suite. "Graphical weather still depends on the connectivity capabilities of each customer," says Marwaha. "Weather via WSI Pilotbrief Optima is automatically updated if connectivity is available, and graphical weather can also be provided. Prompting for updates by flight crew is not required." Transmission rates needed for PilotBrief Optima's graphical weather and update provisions are in the region of kb/s, rather than mb/s. "This varies based on the coverage area, the zoom level and the data that the operator wants to be displayed," adds Marwaha. "The size can range from a few KB to a couple of hundred KB."

Thales offers the AVIOBOOK weather module, called Globe, that is fully integrated within the AVIOBOOK application suite. All flight information, including the flight plan, is already available within AVIOBOOK, because AVIOBOOK is integrated with all major flight planning system providers.

The Globe module allows airlines to customise weather update policies. "Because communication costs might limit data download, airlines can choose to allow on-demand updates by the pilot or manage them automatically," says le Mentec. "If the update is triggered manually, Globe will first inform the pilots of the availability of new data to avoid unnecessary downloads."

Globe also allows pilots to see graphical weather overlays on a map and on a vertical display. "Pilots can easily filter weather information they want to visualise among a comprehensive range of weather products, including turbulence, icing and thunderstorms," adds le Mentec. She explains that the main hurdle when it comes to live weather has been the low equipment rate of broadband connectivity solutions. "The most widespread means of in-flight communication, ACARS, enables the in-flight download of limited weather information at a reasonable cost. With the introduction of IP SATCOM, however, the business case for proactively uploading weather information becomes really strong.

"Moreover, weather forecast models are now very accurate and can be used to better anticipate the avoidance of a weather hazard during a flight," says le Mentec.

According to Lievin, the main limitation preventing airlines from achieving live weather updates is the presence on the aircraft of a system that interfaces the EFBs and the connectivity services available. This can be overcome by the use of an AID. "The EFB application interfaces with a C-AID installed in the aircraft," says Lievin. "Interfaced to the C-AID, the device running the weather application can access two types of assets on the aircraft: 1) the available communication means (for example, SATCOM, ACARS, Cellular connectivity; and 2) real-time avionics data (including the flight phase (FP), altitude, ground speed, heading and flight management system (FMS) waypoint). Usually, the C-AID will provide a WiFi service in the cockpit to

SITAONAIR's eWAS application incorporates data from multiple weather providers and can be set up to automatically receive updates inflight, via ACARS or IP broadband. It can also be set up so that pilots can make manual update requests if needed.

interface with the PEDs that host the EFB." Updates provided by the Rockwell Collins system are automatic, so they do not require specific actions from the pilot. Depending on the weather element and the region, the typical refresh rate is 5-15 minutes. Weather is displayed graphically, and in multiple layers, meaning that flight crew can build up or declutter the data made available, according to the weather prevalent in the region.

Panasonic Weather Solutions (PWS) is focused on achieving the highest levels of detail and accuracy within its weather forecasts. It is these qualities, over instant weather provisions, that de Ris explains can optimise efficiencies and safety for operators. "Immediate connection is less of a need for short-haul and regional operators, but the accuracy of available forecasts is consistently important for all carriers," he says. PWS uses high-resolution atmospheric data from TAMDAR sensors installed on 300+ aircraft, along with an extensively modified proprietary 4-D ensemble model, to maximise forecast accuracy. This data is sent via Iridium to PWS, analysed and formed into 4D graphical forecasts. "It is easy to assume live weather is needed to allow better connectivity for alerts and urgent requests. Systems such as ACARS, however, have been designed so that these can be undertaken using basic connections," continues de Ris. In de Ris's opinion, long-haul flights will see faster adoption of live connectivity. "This is largely because of the industry uptake in broadband connectivity on the aircraft used for these flights. What was once a revenue source for the airline, can now become a valuable tool for operators to improve safety, increase efficiencies, and collaboratively share data between crews," he adds.

SITAONAIR's eWAS app is created in partnership with software company GTD. It brings together weather data from multiple providers, including Schneider Electric, Meteo France, Jeppesen, NOAA and The Weather Company (formerly WSI), plus other leading data providers, according to Tucker. It is supported on Windows and iOS devices, including Surface Pro, iPad and iPhone.

"eWAS can be set up to automatically receive the latest weather awareness updates from multiple sources directly to the pilot's EFB, tablet or smartphone, over ACARS or IP broadband inflight, and cellular or WiFi connectivity pre- and post-flight," adds Tucker. "A manual mode is also available for pilots to send update requests to the ground server."

eWAS also provides graphical weather overlays. "eWAS improves the pilot's situational awareness of significant weather by providing a real-time, graphically-optimised view of weather sources, forecasts and current information, covering the horizontal and vertical planes," continues Tucker. "For dispatchers, eWAS weather data can also be overlaid onto SITAONAIR's AIRCOM FlightTracker, improving dispatchers' overview of the flight context."

According to Tucker, the development of mainstream live weather usage has been delayed for several reasons. "For an airline to take on an EFB weather programme, a clear set of ROIs (return on investment) must be realised to justify the investment," he says. "There are also certain prerequisites." These are:

- An EFB – commercial tablet affordability has now led to the widespread adoption of EFBs.
- An app that can intelligently render the weather data.
- An AID. "To benefit from the full set of ROIs you need an AID to connect the eWAS app in-flight to receive regular weather updates," advises Tucker.
- Operators also need a weather provider that can provide data in both forecast and nowcast datasets. "Forecast and nowcast data has greatly advanced in terms of the accuracy and frequency of new data available," continues Tucker. "Inflight updates of nowcast data are revolutionary compared to the pilot getting airborne with static weather charts that cannot benefit from updates. Updated nowcast data, on events such as CB thunderstorm cells, enhances the pilot's strategic decision-making. This complements the on-board weather radar's strategic and tactical views and decision-making, as apps, such as eWAS, provide prior alerts to events that might need to be avoided."

Hardware & software

Airlines need three basic elements to provide live weather updates that match their operation. "These are a portable EFB, an associated application by a weather provider, and appropriate connectivity that meets the airline's individual requirements," says Horsager. "Airlines trialling live weather prefer no additional hardware to simplify the test process and minimise investment. Using Gogo's services means that if customers already have passenger connectivity, then no extra hardware is required, making live weather provision relatively easy to achieve." For customers without a new-generation connectivity system, however, hardware inevitably needs to be installed. "Broadband connectivity such as Gogo's 2Ku in-flight internet requires antennae, an on-board server and access points and modems," adds Horsager. "Also, airline data should be accessed via a separate network. The cockpit should preferably use a dedicated private network."

"The minimum requirement is a display where the weather application shows its HMI and runs its algorithms," adds Lievin. "This can be via a PED or an avionics display systems on the last-generation cockpits. An example is Proline Fusion avionics suite. Also, the application needs to access at least one communication system to receive weather data updates." Again, it is the airline's request or reply requirements that decide the transmission capabilities needed by the connectivity system on-board.

"Live weather can be received in three ways: ACARS communication, cockpit SATCOM or cabin SATCOM," says le Mentec. "Hardware and software requirements differ highly for each communication system. Updates through cabin SATCOM only require a WiFi connection from the tablet to the SATCOM router. Stringent security layers are requested if the EFB is also connected to the avionics.

"Updates through ACARS or cockpit SATCOM require an AID or an aircraft server with ACARS or IP proxy capability. Not all AIDs offer these capabilities, which are crucial to enable the EFB to access these aircraft communication means," continues le Mentec. "Some Windows tablets, such as the Thales Pad, can be wired to the AID through an Ethernet protocol. For other tablets a WAP (with Bluetooth or WiFi connection) is required to transfer data from the AID to the tablet."

Combining detailed, regularly updated weather within a graphical report, and then overlaying this on a flight plan is a natural step for long-haul airlines. This is the most demanding model to achieve connectivity-wise. "Having both route and weather overlays in context to each other, and therefore in one view increases situational awareness for flight crew, because they can anticipate if critical weather is to be expected during flight," says Wipplinger. "Weather updates in this format are not 'live'. Second-by-second, dynamic updates are not possible, so the most frequent updates in this format are at five-minute intervals, if requested by the pilots." Lufthansa Systems has graphical overlay provisions within Lido's eRouteManual.

Tucker explains that an interface needs to be established between the EFB's flight planning and weather application providers to allow a graphical overlay of live weather over route plans within an EFB app. "eWAS is very flexible in this regard," he says. "Flight plans can be fed directly into eWAS using the industry standard AEEC 633 format by an airline's flight planning provider. We appreciate that not all flight planning providers offer this service, however, and we can work individually with airlines on a case-by-case basis to translate and ingest almost any other type of source flight plan."

The live weather that can be displayed on eWAS's graphical overlay includes rapidly developing thunderstorms (RDTs), lightning observations, icing and local pilot reports (PIREPs). "These are all near-real-time observations depending on transmission lag," says Tucker.

The transmission rates to provide this service varies, as Tucker explains. "Due to the varying nature of weather, data-sizing for weather applications is not an exact science yet because it literally changes from one day to the next. This depends on the weather encountered and the number of weather phenomena chosen by the airline," he says. "Our estimates, however, have shown that an aircraft can need as little as 0.2Mb of data per hour, update the more rapidly changing significant weather types inflight. That said not every hour of flight will need these updates since some flights will be clear of significant weather. Some short haul flights will not require an

The degree of requirement for 'live' weather will vary from operator to operator. Short haul, European operators will likely not require instantaneous updates to the extent that long-haul carriers that operate in remote regions might.

inflight update since the data refreshed on the ground is accurate enough for the sector since we provide a one hour forward-forecast view of where that Nowcast phenomena is moving to or growing/dissipating in strength."

"To display weather layers over route plans in an EFB app, the solution must be integrated with a system that has a digital copy of the flight plan (the operational flight plan module of AVIOBOOK for instance)," says le Mentec. "The EFB must be capable of acquiring this flight plan as well as geo-referenced weather information in different formats, including images, polygons and grids. The EFB, therefore, needs to support a map component capable of displaying this geo-referenced information."

"Currently, the weather application needs either a link to the FMS, or to be able to process the latest AIRAC data," says Lievin. "When connected to the FMS, no specific input from a pilot is required because the app retrieves the current/selected flight plan from the avionics. In future, the EFB application will be able not only to read the current flight plan, but also to push an updated flight plan to the FMS. This will allow the FMS to take into account a deviation due to a CB alert, for instance."

"A few customers are already using AVIOBOOK Globe with graphical weather overlays, but not in flight," says le Mentec. "We are working on adding live weather data updates in flight. The first type of weather product we will add is airport weather information through ACARS." AVIOBOOK's weather service provider is DTN, which le Mentec says provides automatic weather updates at regular intervals.

Reliable weather

The question appears to be what type of weather update meets an airline's requirements. This depends on whether the carrier is a regional, short- or long-haul provider. "The question is what is live weather, and how 'current' does the information need to be," says de Ris. "For instance, if an operator's idea of live weather is an application that updates flight crew before departure, is live weather a highly accurate forecast that updates regularly, or is it the update of METARs and TAFs en route? Does a pilot need to be able to make requests for sporadic weather updates, for instance?" The most extreme sense of live weather would involve the continuous, self-updating stream of data to a graphical overlay of weather on the flight plan. "Live weather is very achievable today, because connectivity is ubiquitous," adds de Ris. "Operators originally saw its use for IFE a source of revenue and customer comfort enhancement, but operational use has been the natural extension."

For PWS, live weather is on the horizon, but its strategy remains to create, so that airlines can obtain, the most accurate forecast possible. "The level of true live weather available is limited to winds uploads, used by airlines for route optimisation in-flight," adds de Ris. "An accurate forecast updated before departure may be perfect for operators on 3-4 hour flights, because safety-related alerts can be handled through light communication channels, such as ACARS." PWS is working with potential partners to develop or enhance live weather-capable EFB apps.

"Live weather information can also support decisions for diversion in case of emergency," says le Mentec. "In such a scenario, the pilots' workload is very high. A clear picture of weather at potential diversion airports, as well as time to destination, taking into account latest winds and fuel information, can help with decision-making.

"Live weather data can be interfaced with a notification app within the EFB to report encountered turbulence," adds le Mentec. "This information can be shared with subsequent flights on a similar route even among different airlines."

Wipplinger explains that there have been some regulatory concerns regarding the relationship between the EFB, aircraft systems and the weather provider. "Some authorities believe that the operator should use the same weather source for both flight plan and live weather updates," he elaborates. "Airlines may need approved weather sources to display graphical weather in conjunction with a flight plan on an EFB application."

"This new wave of next-generation connectivity solutions has only been available in the last two to five years," says de Ris. "It is now a question of what else this capability can unlock. It comes down to which areas of operation this data can enhance – if you are providing accurate, feature-rich information to pilots in a manner best suited for use in a cockpit then you are enhancing the efficiency of the flight, which is airlines' second priority only to safety."

The greater ubiquity of new-generation connectivity, in conjunction with apps to process in-flight data efficiently, has led to airline-led initiatives to install live weather. According to Wipplinger, for instance, most airlines plan to host real-time weather in the next two to five years.

Alaska Airlines is trialling real-time connectivity for its weather data. Until now, weather data has formed its operational dispatch and pre-flight documentation, and ACARS used for AOC messages. Alaska is now exploring cellular and satellite connectivity options, and the potential for graphical weather overlays on its flight plan, albeit in a simulated environment. - *CLD* AC