Flight data encompasses a broad range of information that can now be accessed before, during and after each flight. Big data analytics and improved connectivity have enabled operators to extract information to improve operational efficiency. Charlotte Daniels examines the capability of these emerging technologies, and the potential for further benefits.

Exploring the benefits of big data analytics in airline operations

Once used purely for safety and training purposes, flight data and its analysis now has the potential to offer more for operators. There are many facets to a single flight that can influence operational efficiency. Detailed analysis of aircraft data with big data analysis platforms can help educate operators to improve a large number of operating processes, and ultimately help them to realise savings in many elements of their operations and provide a more reliable service.

The various stages that airlines are at with regard to the true utilisation of their flight data will be explored. Is this data purely utilised for the purpose of flight safety, for instance, or has there been proven benefit of the detailed analysis for its place within flight and ground operations? If so, which potential saving is most important for operators as the next step? Is cost the next main issue after safety, or is it increased efficiencies in operations, such as quicker turnaround times, flight routes that are weather-sensitive, or enhanced communications?

As outlined in the description of the principles and benefits of big data analysis *(see Applying e-Enablement and big data analytics to techniques in flight operations, Aircraft Commerce, October/November 2016, page 34)*, the use of integrated systems, electronic applications and increasingly sophisticated data processing platforms has allowed System-Wide Information Management (SWIM) to mature, so that full utilisation of flight data has the potential to benefit not just safety departments. There remain limitations to this progress, however, including the cost of implementing new data platforms that can process Big Data.

Southwest Airlines operates an average of about 3,800 flights per day, for example. When considering the parameters that need to be measured per aircraft per route performed, the true volume of data that is uploaded, and can therefore be analysed, is exceptional. Systems need radical revisions to accommodate this.

While Cloud-based platforms can help the implementation of suitable data-mining systems, other changes an airline makes still happen incrementally, slowing progress. This includes overhauling standard operating procedures (SOPs) to allow for e-enabled processes, such as the incorporation of an electronic technical log, for instance. As highlighted in the previous issue, the true gains that flight data analysis can offer will only be achievable after an airline is able to analyse all the elements of its operation in detail. The process by which an airline will become fully e-enabled is taking time, however.

By focusing on particular areas where flight data can benefit operations, airlines are gradually adapting systems and infrastructure to accommodate Big Data. "Airframe Health Monitoring (AHM), and wireless data transfer have allowed operators to take advantage of real-time flight data, for instance," explains Juergen Holzner, manager for flight data analysis programme (FDAP) at Southwest Airlines. "This access to data allows us to ensure that, in the event of a fault occurring in flight, we have mechanics ready on-stand to rectify the issue by the time the aircraft lands."

The key areas that can benefit from flight data monitoring (FDM) include flight safety, aircraft maintenance, flight operations and ground operations, fuel burn, airline overheads, and passenger services. While, naturally, flight safety remains the priority for all operators, what follows next? Is it quicker turnaround times, cost savings, or fewer flight delays?

An airline's cost index signifies its own priority for flight data, such as whether it ranks cost over time during a given flight, or vice versa. Used by the flight management system (FMS), an airline's cost index is the ratio between flight time and fuel consumption. The ratio can influence the direction an operator takes when further using its flight data to positively improve operations. "If the ratio is low, this suggests that achieving low fuel consumption is a high priority for the operator," explains Pierre Jouniaux, founder and chief executive officer (CEO) at Safety Line. "If the cost-index is relatively high, however, then an airline's main focus is time-efficient and shorter flight times that may burn slightly more fuel in the climb, for instance. These considerations need to be taken into account when tailoring fuel efficiency software for customers."

FDM & FDA

The main focus of FDM remains enabling the identification of potential hazards. A robust safety management system (SMS) that recognises and promotes the frequent analysis and monitoring of such data ultimately helps to improve a risk mitigation programme for operators *(see The principles of safety management systems (SMS) and their use,*

The key areas of an airline's operation that can benefit from flight data monitoring (FDM) include flight safety, aircraft maintenance, flight operations and ground operations, fuel burn, airline overheads, and passenger services.

Aircraft Commerce, December 2013/January 2014, page 23). As described in the article, FDM programmes have been able to automatically generate hazard warnings or process the appropriate data for airlines to identify potentially hazardous events. This can be achieved if certain parameters, such as engine oil temperature or exhaust gas temperature margin (EGT) are defined by the original equipment manufacturer (OEM) and operators, and programmed into the FDM system accordingly via algorithms.

Based in Malaysia, AirAsia operates a fleet of A320s. With the introduction of the A320neo and A321neo to its fleet, it is updating its flight data analysis systems to incorporate the capabilities and increased connectivity seen on new-generation aircraft. The emergence of big data, brought on by the increasing access to health monitoring and sensor information generated on board these aircraft, has led to the need for an overhaul of AirAsia's data-processing systems. With flight data growing more and more complex, AirAsia has now installed a Big Data-capable platform to process it. AirAsia explains that this allows them to focus on important issues, and take care of all the required data mining."

An increasing number of sensors is being installed on aircraft, allowing more information and insights to be revealed to airline operators, AirAsia explains. As operators approach the Internet of Things (IoT), the plethora of information must also be properly managed by these Big Data-capable platforms.

AirAsia has introduced wireless connectivity across its A320 fleet, to offer connectivity consistent with its A320neos, delivery of which has begun. AirAsia can now monitor flight data minute by minute, and transfer it wirelessly from the aircraft to secure company servers on the ground via an encrypted connection. This data is then processed and stored immediately upon receiving.

AirAsia's management team has full access to real-time information, arising from flight data, via several access portals. Performance indicator reviews are then tabulated at monthly departmental meetings, as well as quarterly board meetings.

Fuel burn, aircraft gross weight, and block times per flight are some of the many parameters that AirAsia closely monitors and uses for its operational optimisation projects.

New technology is being developed to help older aircraft become further FDM-compatible. Airbus has commenced a programme with Rockwell Collins, to offer a retrofittable, enhanced Interface and Communication Unit (EICU) for A320 and A330 families. Designed to improve the interface between an electronic flight bag (EFB) and an airline's operations department, the EICU allows wireless data connection to the EFB device inflight, and a gatelink connection for pilots before flight, whereby they can access flight calculations without needing to input data manually. Flightcrew will also be able to view current FMS parameters, obtain real-time positioning, fuel remaining and consumption rates. The EICU will enter into service on an A320 family aircraft in 2017.

AirAsia explains that in terms of flight data analysis (FDA), it programmes each aircraft in its fleet to select raw signal outputs from various sensors and record them on a customised data stream. This data is processed into useable information and distributed within AirAsia's safety, engineering and flight operations departments.

Raw flight data, once processed by the flight data analysis tool, is kept on a secure SQL database. The software is fully customisable to the needs of different groups of data end-users.

A team of aircraft performance engineers is designated by AirAsia to closely monitor each aircraft's efficiency indicators through flight data, and also perform route feasibility calculations. These calculations are essential to route and network management activities for the operator.

AirAsia is collaborating with General Electric (GE) to transform its flight data into a tool for monitoring and enhancing flight efficiencies. It typically analyses raw flight data combined with flight planning information, which allows the airline to project accurate flight performance indicators for each flight such as block times, fuel burn, and APU usage among others.

Many elements affect the efficiency of flight, ground and maintenance operations. These combine to affect the overall running of an airline's entire operation. The use of Big Data can help to streamline the communications between these elements, and enhance efficiencies.

Not all operators are looking to expand FDM beyond safety management. Another global operator, Air France, remains focused purely on using flight data to maximise flight safety and strengthen its safety management system. Through its use of FDM, Air France is taking advantage of various technological advancements to enable flight safety to reach its full potential. Headquartered in Paris, it operates a fleet that is diverse in terms of size and age, including 777s and A320s, A330s, A340s and A380s. Due to the natural differences in on-board systems between the types, Air France has to incorporate a variety of connections to effectively monitor the data streams that arise from each aircraft. The airline explains that while all data originates from the Flight Data Recorder (FDR) on board, data connections used between aircraft types include: wireless transmission, such as cellular connectivity or on-board wireless hubs; and physical supports such as optical disks and personal computer memory card international association (PCMCIA) cards that record the data and then have to be manually removed to upload information onto Air France's systems.

Data coming from WiFi- or cellular-enabled aircraft feeds directly into Air France's FDM systems, whereas data from optical disks and PCMCIA cards has to be converted using software once uploaded. Air France uses wireless data transfer for its A380, 787 and youngest 777s. Its A320 fleet incorporates both optical disk and PCMCIA cards. Its A330, A340 earlier 777s rely on optical disk only, for data downloads.

According to Air France, through supplier software and by using Air France generated algorithms, during the processing of its flight data the FDM system performs measurements per flight such as landing distance, braking distance, and vertical deceleration at landing. This allows any operational events that pertain to flight safety to be identified. This data is then further used by Air France to perform risk assessments as part of its overall safety management system."

Air France's FDM systems include Safran's SAGEM Analysis Ground System (AGS), which is programmed and customised using Air France algorithms, and CAE Flightscape. CAE Flightscape's FDM software is called Insight FDM, and allows flight data to be configured into graphical reports that easily highlight appropriate information, such as unstable approaches: high aircraft bank angles or high vertical speeds, during each phase of flight.

As described, data is only monitored by Air France to enhance overall flight safety. The airline explains that key goals are to identify risks, measure them and minimize them. Air France further explains that FDM and its use of flight data is conditioned by an agreement with its pilots union.

The AGS data-processing FDM software that is utilised by Air France is also installed with a further 80 airlines worldwide. Developed by Safran Electronics & Defense (SED), the AGS is therefore currently processing flight data for about 6,000 aircraft across the globe; collating trending information from about 2.5 million flight hours per year.

Customers that install the AGS are able to configure the system to recognise and transform raw flight data, based on the specification of their fleet FDRs/QARs. Once the AGS is configured, all flight data is processed automatically onto the operator's server via an input directory. As explained by SED, the customer is subsequently able to code algorithms to compute measurements that they want monitored. There are about 200 parameters that are relevant to flight safety, for instance, which would naturally be a requirement for all customers. Those with maintenance departments, however, may wish to monitor additional parameters such as engine information, landing gears or flap sensor performance.

While these 80 airlines have installed and independently manage the day-to-day running of the AGS, Safran explains that there are other smaller or regional operators that wish to use a data management service instead. This requires them to send raw flight data to Safran on a regular basis, so that Safran can process the raw data and convert it into a readable format, and compute analytics that are made available to the customers via a web application. The data management service that is offered by Safran is called Cassiopee FDM, and is a popular option for those airlines wishing to explore the additional benefits that FDM can offer without the requirement to invest in installation costs, or a team of flight data analysts. Safran has a further 80 airlines using the capabilities of the AGS on this basis; covering an additional 350 aircraft in operation worldwide.

"While most customers still remain focused on FDM for flight safety, other customers are now investigating FDM's potential in airworthiness maintenance and flight operations," confirms Laurent Kokanosky, head of flight data analysis at Safran Electronics & Defense. "This is partly because there are parameters that can be measured on aircraft today, which

Southwest Airlines has been utilising FDA in its Holdover Time (HOT) studies to establish at each airport operated, the most accurate timeframe that de-icing fluid will remain on the wing when aircraft are on the ground.

simply were not previously available.

"While the 737 Classic, for instance, offered operators dozens of parameters to measure, its successor the 737NG introduced hundreds of additional measurements. And now the 737MAX, or the A350 is capable of providing thousands more for operators that wish to learn more about their operations," continues Kokanosky. "The capabilities of these aircraft to record and store this data have also become more sophisticated in order to make the data more transparent for airlines. Whereas the FDR used to be the hub for all recorded data, systems such as the ACMS now provide platforms for the increased volume and types of data such as DAR and SAR." To put this into context, the AGS processes up to 10TB of flight data each year.

The ACMS is capable of sending data wirelessly to customers. This is via a wireless extension for the ACMS (WEFA) and is available to customers on a complete data management services agreement. For those aircraft still reliant on PCMCIA cards, simcards can be used that enable the cards to connect via a cellular connection and transmit data accordingly. "Our customers can choose when to use this capability," adds Kokanosky. "Operators may not wish to use cellular connectivity in aircraft where roaming data charges will occur, so they will switch off the transmission."

Air France can monitor flight data daily, converting it into key performance indicators (KPIs) that are reviewed every month. Key risk assessments conducted by the operator include mitigating runway excursions, and ultimately loss of control by flightcrew. About 40 people including pilots monitor this data, each trained in statistical analysis and the programming of algorithms.

Preventative maintenance

Given the increased information presented by on-board sensors, preventative and predictive maintenance has become one area of focus for operators. KLM Airlines, for instance, distributes all flight data to its engineering department Air France KLM Engineering and Maintenance (AFI KLM E&M). By doing this, the airline hopes to avoid unforeseen disruptions in its flight operations. In order to continue its evolution into becoming an e-enabled airline that uses Big Data to its full benefit, KLM Airlines has acquired new FDM software, CAE Flightscape and Boeing AHM. This software enables the airline to process larger volumes of data. This year KLM will explore the potential that these enhancements will have to offer by introducing predictive maintenance operations across the company.

AirAsia has been able to use its A320 fleet data to the extent that preventative maintenance, such as the replacement of a part before it becomes faulty, can now be planned into aircraft rotation schedules. This is not only beneficial to enhancing maintenance efficiencies, because one can expect that unexpected findings during routine or line maintenance will decrease for operators. This will therefore have a positive effect on turnaround times (TAT). Moreover, preventative maintenance benefits flight operations as will be outlined.

As a maintenance organisation, the main focus for Etihad Airways Engineering is the potential for flight data to enhance maintenance efficiencies. The recent emergence of big data has allowed the concept of preventative maintenance to flourish *(see Spare parts supply chain management, Aircraft Commerce, August/September 2016, page 53)*. Etihad Airways Engineering subsequently accesses and analyses data from a variety of different sources for this purpose. "We analyse wireless quick access recorder (WQAR) data, aircraft condition monitoring systems (ACMS) reports, technical log reports, maintenance system and reliability data," explains Jeff Wilkinson, chief executive officer at Etihad Airways Engineering. "We mainly use the aircraft manufacturers' tools such as Boeing's AHM and Airbus's AIRMAN to provide this data."

"The bulk of the data belongs to the Safety & Quality Department where it is used for safety-related matters," continues Wilkinson. "The data will eventually be used to provide notice of impending system failure, and therefore keep the operation of our fleet to the scheduled departure times."

Etihad Airways monitors data sent by the aircraft communications addressing & reporting systems (ACARS). Two key elements that its engineering department monitors include engine fuel efficiency and auxiliary power unit (APU) usage. "The operations department at Etihad Airways develops the data derived from ACMS reports into KPIs, which are analysed for anomalies," adds Wilkinson. These reports are then distributed to the wider company and Etihad Airways Engineering.

According to Wilkinson, all the flight data derived from these systems is encoded using various aeronautical radio incorporated (ARINC) data formats. ARINC refers to the foremost technical standard seen on most commercial aircraft. It defines the physical and electrical interfaces of this data and its supported interaction with the local area network (LAN) of an aircraft's avionic system. Etihad uses mostly OEM systems to monitor flight data, although it continues to explore new platforms.

Etihad's systems 'read' the data and identify anomalies via co-developed algorithms between it and the OEMs. "We start with identifying pain points in

the operation. Then we develop 'alert levels' and algorithms together with the OEM to suit our business needs," says Wilkinson. "The pain points are generally defined as leading delay drivers and disruptors to the operation."

The potential the flight data has to improve MRO operations, and customer experience, are areas that Etihad sees as key to exploring its potential. "We do not expect changes to flight or ground operational standards," says Wilkinson. "An extra level of detail is always helpful when troubleshooting during maintenance, however.

"Flight safety and guest experience are always areas to be maintained," continues Wilkinson. "Disruptions, delays and unscheduled maintenance are costly and need to be kept to a minimum. Generally, using flight data for awareness of aircraft system health will remove the operational surprises and costly unscheduled maintenance.

"While Engine Health Management (EHM) began more than 30 years ago. Aircraft Health Monitoring System (AHMS) came more recently, and the introduction of cabin health monitoring (CHM) has begun. This is a direct result of highly complex premium cabins and the higher expectations of the guest. Why wait for the guest to discover the faulty recline actuator, for example, when a health monitoring system can do so beforehand?" adds Wilkinson. As highlighted by previous articles, if a 'no-go' item can be flagged to maintenance before it becomes faulty, either mid-flight or during a line inspection, then proactive remedial action will have a positive knock-on effect to flight operations, by mitigating against an aircraft going 'tech' due to unforeseen disruptions. "The effect on flight operations is a higher dispatch reliability," adds Wilkinson.

Wilkinson explains that flight data, whether it is recorded fault data, continuous parameter log data or reliability data, is analysed every day by the company. Depending upon the data importance; safety, performance or maintenance data is used every day in the operation at different levels. "Each department has subject matter experts, who analyse the data for different information," continues Wilkinson. "Safety and Quality personnel look for flight operations trends and post-incident reports for instance, whereas the Engineering department requests details after specific maintenance events.

"Our Flight Operations department has evolved independently using its retrospective flight data tools," says Wilkinson. Etihad has experienced a significant surge in flight data usage in recent years. "More flight data monitoring is carried out than five years ago. This is because more data is available, and next generation aircraft also share this data directly with the OEMs," says Wilkinson.

"The potential for flight data to introduce 'predictive maintenance' is a big focus at Southwest," adds Holzner. "One of many examples is using flight data relating to the flap position sensor. By using historical data we have been able to deduce that these sensors can take three to five weeks to become unreliable. After this, the flap position becomes inaccurate, resulting in stuck flaps and a message is sent to the cockpit, causing an operational disruption while the sensor is repaired or replaced.

"We have therefore been able to make this particular sensor a focus of our maintenance report," adds Holzner.

Ground & flight operations

Headquartered in Dallas, Texas, Southwest Airlines' fleet consists of over 700 737s. At Southwest, flight data is analysed by the Flight Operations Safety department, which then passes it among other departments as necessary. "Passing all FOQA flight data via the Flight Safety department allows us to determine which departments will most benefit from using particular data," explains Holzner. "A

Etihad Airways Engineering is exploring the benefits of FDA to enhance its maintenance operations. Specific data analysed includes engine fuel efficiency and APU usage.

designated team of six analysts focuses purely on monitoring this data." It is the benefits that FDM can bring across the entire company, rather than just operations, that forms the secondary function of flight data for the operator.

"Dedicated teams were introduced when the concept of big data emerged," continues Holzner. "When you consider the new-generation aircraft that are beginning to appear, there is a clear need to increase the data being made available to operators. While the 737-800 records over 1,000 parameters, for example, including atmosphere, automation, hydraulics and pneumatics; aircraft such as the -8MAX now have more than 15,000 parameters to monitor."

Southwest reviews flight data daily, Holzner adds. Parameters, such as upper and lower limits are developed for each data segment by the team of analysts, who develop appropriate KPIs to reflect their findings. "There is a person supporting each separate department and developing focused reports," continues Holzner. "To date, we have been able to use the data passed to these departments to determine, say, whether newly designed approaches by the Federal Aviation Adminstration (FAA) are actually beneficial. We have also been able to validate flight paths as a result of FDM."

After flight safety, flight data's role in enhancing operational efficiencies is of key interest for Southwest. "Southwest tries to make as much use of flight data analysis as possible," explains Holzner. "This extends beyond operational procedure, affecting even wider departments including legal departments and environmental services to name a few. Operations would like to utilise data relating to taxiing aircraft to and from hangars."

With regard to its ground operational efficiencies, one of many areas of focus was flight data usage in the past in reference to Southwest Airlines Holdover Time (HOT) at specific airports. HOT provides the approximate time that de-icing fluid, once applied to an aircraft, can remain effective. "Ultimately, HOT studies, combined with more comprehensive flight data, can determine with greater precision the time an aircraft can remain on the ground before it requires de-icing again," explains Holzner. "Southwest uses historical FOQA flight data to determine the average time aircraft remain on the ground.

"We combine this historical data with weather data on the day, such as wind speed and heading," adds Holzner. "This allows us to determine the HOT with greater accuracy. We even use weather patterns and the positioning of the aircraft to establish whether de-icing fluid is staying on or running off the wing, which also affects the HOT." Midway is a prime example.

Southwest focuses more on the fuel savings that can be made on approaches, than flight routes. Again, using FOQA flight data the operator has noted seasonal trends in its approaches, such as the climb or descent performance differing from spring to winter. Southwest can now use data to see where opportunities to improve efficiency may lie.

Flight data analysts raise observed data that needs attention during Southwest's monthly review board. This review meeting can establish which department data is likely to benefit from emerging data trend observations. Single engine taxi has been a topic of discussion, and after data analysis Southwest has recently changed SOPs by reflecting new processes in pilots' pre-flight checklists. These changes are in reference to aircraft configuration.

Climb profile & other fuel efficiencies

A critical phase in flight, on which operators can expend considerable amounts of fuel, is the climb. Once an aircraft has reached its cruise altitude on a given route, this is generally perceived to be the most fuel-efficient stage of flight. The climb, therefore, is one main area of focus for operators. If an airline can save fuel every flight during the climb phase, this has significant cost-saving implications across the organisation. Software that allows operators to optimise their flight plans to accommodate the most fuel-efficient climb profile, taking into account a wide range of daily variables, is naturally very attractive to airlines wishing to use FDM to benefit flight operations.

Developed by Safety Line, OptiClimb is one such software. "The concept behind OptiClimb is to determine, using true data, the best climb profile for each individual aircraft," explains Jouniaux. "The climb profile can vary from aircraft to aircraft, depending on myriad factors, including but not limited to weight (both payload and modification status), age, route performed (and the weather encountered), altitude undertaken on the day and a result of the weather and route profile."

OptiClimb is a fully automated software as a service (SAAS). No equipment or hardware investment is needed to incorporate the software into an airline's flight operations. "For each new customer, OptiClimb is calibrated and adapted to its own fleet by taking the Quick Access Recorder (QAR) and historical data downloads for a minimum of 200 flights," continues Jouniaux. "The raw data from these files establish basic parameters that reflect an operator's habits and flight patterns, such as typical routes, payloads, flight and block times,

Several airlines are now using Big Data analytics for the purposes of preventative maintenance. These include KLM, Etihad and AirAsia. Applications include predicting parts and component failures.

and average fuel consumption. This raw data provides a customised benchmark from which to compare true data for each future flight."

OptiClimb subsequently uses this data, combined with weather data on the day, to determine the most efficient speeds to perform at given altitudes on a per-flight basis. "Once a flight plan (FPL) is created by the client's operations department ahead of a flight, OptiClimb will then extract details from the FPL including weight, wind profile and altitude," adds Jouniaux. Combining this data with the historical data enables OptiClimb to determine the most efficient speed and altitude to use in accordance with its client's cost index. The system therefore sends back three speeds to correspond to respective altitudes in the climb out and normal climb phases to generate the most fuel-efficient profile. "These speeds are fed into the EFB for the flight crew to access," continues Jouniaux. "The captain then programmes the autopilot accordingly before the flight. If the operator does not yet use an EFB, than these speeds form part of the paper-based pre-flight briefing pack handed to the pilots."

Safety Line has been making further investigations into how its software can offer more detailed FDA to customers through enhanced weather data. In November 2016 it announced a partnership with Panasonic Weather Solutions (PWS) whereby it will provide even more accurate weather forecasting data to users of its OptiClimb software. This data comes from collating about 3,500 flight profiles globally, sent from aircraft that are equipped with Tropospheric Airborne Meteorological Data Reporting (TAMDAR). TAMDAR data is sent back to PWS via Iridium in real-time, and this data is converted back to Safety Line's software to enable greater forecasting abilities. It follows that the more accurate the weather input is, the greater the optimisation of the OptiClimb software for customers.

Safety Line is also looking to incorporate landing trajectories and taxi times with its software, to provide even more accurate fuel burn analysis. It is working with 4-dimensional (4-D) trajectory models to predict aircraft movements as a result of external variables such as weather, in order to further establish efficient flight routes for customers. Last, it is working together with Airbus and Paris airport authorities to monitor braking action and RADAR data, in order to enhance turn around times for customers.

"OptiClimb is able to offer further FDM potential for operators, because the software closes the loop between historical and real-time data," adds Jouniaux. "As daily data continues to feed into the system, more accurate data is therefore generated. This can be used to improve the operator's fuel efficiencies, and provide greater cost savings." Jouniaux concludes by saying that it is worldwide connectivity, such as wireless-capable aircraft, that will truly enable the full potential of flight data for operators.

Six customers are trialling Safety Line's OptiClimb software, including OptiClimb's launch customer Transavia France, which commenced trials in April 2016. In January 2017 it rolled the software out across its fleet.

Transavia France's fleet consists of 26 737-800s. "We use OptiClimb to determine per tail, the best climb profile in accordance with weather and weight on the day," says Emmanuel Cachia, director of flight operations at Transavia. The information provided by OptiClimb is synchronised with Transavia's digital flight file, which is Aviobook. The integration between the software enhances operational processes overall, since using a digital flight file saves time.

Rather than invest in expensive and complex platforms to handle and process Big Data, Transavia enlists the services of contracted specialists to analyse and feed back on data it selects as most relevant to enhancing its operations. This allows the airline to benefit from suggestions on how to enhance its operations without the need to invest in an FDM team itself. Safety Line is one of these specialists, and OpenAirlines is the other. While Safety Line is charged with analysing climb profiles, Open Airlines is used to investigating fuel burn during the taxi. "After safety, cost is the main driver for Transavia's operational set-up, so saving on fuel is one focus when using flight data," says Cachia. "Now that we been able to increase fuel efficiency during aircraft climb, we are focusing on consumption during taxi time to see how we can adapt the fuel allocated according to the season and airport. This is also

The operators' cost index will influence the nature of its preferred climb profile. Those choosing cost-saving as a priority will opt for the most fuel efficient profile, while time-efficiency will require a profile that burns slightly more fuel, according to Safety Line.

important for flight safety." Using the information fed back by OpenAirlines, Transavia has been able to establish a dynamic approach to fuel uplift, by altering the fuel required per airport. "As standard, we always allocated 200kg of fuel for taxi times," adds Cachia. "This is not always necessary, however, if taxiways at an airport are shorter than average.

"Due to the analysis of our historic data by FDM specialists, we can specify the fuel per trip with greater accuracy," continues Cachia. "By evaluating previous flights in our route network, we have been able to establish how much fuel is actually used for taxi at each airport. Paris-Orly Sud, for instance, uses about 200kg of fuel in the average taxi during winter operations, and 180kg of fuel during the summer-time."

Transavia receives KPIs from Open Airlines on a monthly basis. These KPIs promote 'five best practices', that indicate how flightcrew can best preserve fuel usage in the taxi, in addition to exploring continuous descent approaches, (CDA) and reduced acceleration altitudes (RAAL). "These KPIs might suggest when to use reverse thrust, or engine-out taxi at particular airports, for example," adds Cachia. While the KPIs generally apply to the whole fleet, they can be tailored to a specific aircraft if Transavia needs more detailed input, due to its modification status or age.

Transavia sends flight data to its contracted data analysts every three days by email. This flight data is downloaded from PCMCIA cards on board the aircraft. "The results fed back to us as KPIs are analysed monthly by our flight operations management crew," continues Cachia. The KPIs are also distributed to pilots on this basis, for additional input. "Every three months a wider result is shown to the management board, and our fuel budget for the next quarter is determined based on this increasingly accurate data." The quarterly meetings also provide a platform to discuss new areas of flight or ground operations that could benefit from FDM.

Another fuel-saving concept that Transavia is exploring using flight data, is the optimum frequency for performing engine washes. "Transavia's standard practice is to wash each engine once a month," says Cachia. "We use data feedback from Open Airlines to determine whether increasing the frequency improves the efficiency of the engine, and therefore enhances fuel consumption. Now that we can determine the true cost of our operation, and pinpoint areas where savings can be made using FDM, we can establish the 'best balance' that keeps us efficient but also saves us money. This could mean, for instance, establishing the medium between washing engines too regularly, which would interfere with regular operational demands, and possibly increasing the frequency to more than once a month if FDM proves that there are fuel savings to be had. Overall, it is too early to know the full benefit."

To date, Transavia has saved an average of 100kg of fuel per flight as a result of implementing its new strategies for climb optimisation and adherence to the five best practices for fuel savings. Putting this into context, the operator performed 34,000 flights in 2016, meaning an estimated overall fuel saving of 3,400,000kg in one year. "The importance to us of using flight data is that we are no longer blind to any element of operational cost," summarises Cachia. "As an operator, we no longer just see the overall fuel burn figure per trip, for example. Big Data allows us to break this fuel burn down into stages of flight, and tools are made available that allow us to use this data."

Data coverage & download

Southwest noted a surge in potential for flight data monitoring after the introduction of ACARS. "Today, once electrical power is supplied to an aircraft, flight data can technically be monitored in real time," says Holzner. This enhancement in connectivity, furthered by new-generation aircraft, has enabled the greater use of flight data. For operators with more mature fleets, however, the process of downloading flight data has not yet caught up with new generation technology. The use of PCMCIA cards, for instance, is quite common on legacy carriers. A relatively old technology, PCMCIA cards and other storage devices, have to be physically removed from the aircraft, to be uploaded into an operator's systems. Other older media, such as optical disks, are also still slow to be replaced.

"Even so, capabilities to monitor flight data have improved notably in the past three to four years," explains Holzner. "Six years ago, Southwest aimed for 75% coverage in FDM across its fleet. Due to hardware reliability and the process of data download, however, the rate of successful downloads translated to about 50% of all flights once the PCMCIA cards had been removed and the data analysed.

"Once Southwest recognised the need for more precise data to benefit flight operations, the focus was pushed to the entire fleet. There remain cases of poor

card download or corrupted data, which means in reality our data is gathered from 92% of flights," adds Holzner. The industry average is in the region of 85% with similar hardware.

The introduction of the 737 MAX will introduce the concept of wireless data transfer to many operators. With deliveries pending of the type, Southwest is anticipating the effects of wireless connectivity on its flight data monitoring processes. "Once we have commenced delivery of the -8MAX, Southwest will continue to make enhancements to its fleet to enable wireless connectivity," continues Holzner. This overhaul in data downloading processes will negate the need to physically remove, download and process flight data, in turn promoting 'real time' data analytics. Southwest pulls cards every five to seven days. "The PCMCIA cards each carry 1GB of data, which equates to about a week's worth of flights on average," says Holzner. "Disruptions, such as aircraft going tech down route, sometimes make it impossible to access an aircraft's data in this timeframe, so losses can occur. This is something that wireless data transfer could naturally mitigate."

Southwest has dozens of stations where data from PCMCIA cards can be uploaded. Holzner explains that this data is uploaded onto Southwest's server in specific-to-the-application files. The primary data updated focuses on aircraft performance, weather and airport data. These files are then processed into an application (app) that allows Southwest's analysts to write and recode the data, and create algorithms.

Conclusion

Operators, when promoting the greater potential for flight data in an organisation, advise some caution. AirAsia, for instance, emphasises that trending data, rather than direct analysis of a particular flight, plays a key role in its FDM processes. It is this data that is used to change procedures when appropriate. AirAsia explains that this is because it strictly adheres to a non-punitive policy in SOP monitoring through flight data, meaning that SOP change recommendations arise when safety trends, not particular events, are discovered using the flight data analysis tool.

Operators are consciously distancing themselves from the concept of FDM promoting a 'blame' culture within airlines, instead focusing on the benefits of gaining such knowledge. As an operator, AirAsia avoids using flight data as a tool for punitive action, but rather tries to use the insights gained to improve overall operations.

Ultimately, Southwest Airlines perceives new generation aircraft as setting the standard for flight data monitoring and analysis going forward. "These aircraft are becoming more capable," says Holzner. "For example, there are over 15,000 parameters that we will be measuring on the 737-8MAX when it is delivered. This technology is a culmination of the improvements and enhancements seen through the Classic and Next Generation (NG) versions of the 737 family. An aircraft's flight data output will only increase as technology becomes more sophisticated and adept at processing Big Data." While all FOQA data across airlines today gets passed through flight safety, Holzner explains that in future the on-board servers on new-generation aircraft will be able to distribute data to 'warehouses' where it can be stored, and access granted to authorised individuals within an airline. More efficient access to, and analysis of, data, will lead to benefits for operators that exploit this potential. AC

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