The deadline for airlines to comply with the GADSS mandate is 1st of January 2021. The mandate requires aircraft operators to automate aircraft tracking capabilities. The hardware options available for operators are reviewed here.

The avionic options to comply with GADSS

The impetus for the International Civil Aviation Organization's (ICAO's) Global Aeronautical Distress and Safety Systems (GADSS) standards came from two high-profile aircraft accidents. These were the loss of Air France (AF) 447 in 2009 and the disappearance of Malaysian Airways MH370 in 2014.

Despite flying in surveyed airspace at the time it went missing, AF447 was only found about two years later.

In 2014 MH370 was lost in the Indian Ocean, which is very deep in parts. Usual methods of accurately locating the wreckage have so far been unsuccessful.

Both these accidents raised the question of how it is possible to lose track of an aircraft in the 21st century.

The GADSS mandate will require operators to enhance and automate their tracking capabilities for aircraft in distress, and for aircraft flying off-course.

In addition, GADSS flight data recovery will require the timely recovery of flight data after an accident by one of two modes. One of which is an automatic deployable flight recorder (ADFR) that ejects its memory module when a crash is detected.

The other is the remote transmission of aircraft telemetry for downloading parametric data to ground-based servers. Telemetry can be permanent, where available for maintenance and fuel monitoring, or triggered when an abnormal situation is detected, with the potential to include voice data when an aircraft is in distress.

The introduction of the GADSS mandate means all new aircraft must be forward-fitted with an enhanced automated tracking capability. All new aircraft designs submitted after the introduction of the GADSS mandate must be capable of timely FDR data recovery in addition to having the standard flight recorders.

The mandatory GADSS requirements will be effective from 1 January 2021.

ICAO

A special multidisciplinary meeting on global flight tracking (MMGFT) was convened in May 2014 to propose recommendations for future actions. One of the main decisions taken was the need for operators to pursue aircraft flight-tracking at a faster pace.

It further recommended that ICAO provisions should be developed, using a multidisciplinary approach, to support the location of an accident site in a timely manner for the purpose of search and rescue (SAR) and accident investigation.

ICAO document 10054 gives implementation guidance for the GADSS requirements pertaining to ICAO document Annex 6 – Operation of Aircraft – part 1 applicability.

Annex 6 was updated in accordance with the GADSS concept of operations (ConOps) that specifies the high-level requirements of GADSS. On 2 March 2016, the ICAO Council adopted Amendment 40A to Annex 6, Part I including standard and recommended practices (SARPs) relating to the location of an aeroplane in distress and the timely recovery of flight data.

These SARPs became effective on 11 July 2016 and will apply from 1 January 2021. Implementation guidance is available in document ICAO 10054. ICAO Annex 13 – Aircraft Accident and Incident Investigation. This will be updated to include new documents and amendments pertaining to how data is stored in distributed server networks, such as a data-cloud and accessed and used in an accident investigation.

Current Annex 13 legislation is based around flight data information, including its location during the post-flight location and recovery (PFLR) phase.

GADSS is defined as a performance-based approach, meaning the system is graded on functionality rather than mandating a specific solution.

Background

Modern aircraft have the capability to be connected by digital navigational systems and satellites. Passengers can connect to reliable onboard consumer internet protocol (I.P.) service providers. Aircraft can now reliably access sufficient bandwidth for passengers to make video telephone calls and stream digital content.

Since 2010, the bandwidth available for aviation purposes has increased dramatically, due to improved satellite systems and better economic models; in addition, transmitting basic telemetry has become possible.

After the loss of AF447 in 2009, Air France introduced a telemetry reporting system through Aircraft Communications Addressing and Reporting System (ACARS). At the time the technology available for sending satcom data through ACARS was expensive. The basic prototype system adapted systems that were already installed on the aircraft.

ICAO first adopted Amendment 39 to Annex 6 of its normal aircraft tracking SARPS in November 2015. Phase one of the two-part requirement mandated airlines to track its aircraft operating under normal flight conditions every 15 minutes, with an optional abnormal tracking functionality.

ICAO's 2021 requirement mandates an autonomous distress tracking (ADT) function. This includes a requirement for the airline or a third-party organisation to monitor and report abnormal tracking events, such as an aircraft flying off-course. Airlines will be accountable for any tracking undertaken by a third-party organisation.

Tracking functionality does not introduce change to current air traffic control (ATC) alerting procedures. During the PFLR phase, tracking requirements must guide SAR assets within six nautical miles (nm) of an aircraft's final point of impact.

If the aircraft enters an abnormal situation such as an unusual attitude, speed or track it must go into ADT mode. This means the tracking standards move from ICAO AN6 requirement 2015, to GADSS ADT requirements.

The 2015 requirement is for an aircraft to transmit four flight dimensions of longitude, latitude, altitude and time, every 15 minutes (4D/15) or less. ADT stipulates an increase in the tracking rate to 4D/1 specification, which requires a four-dimensional transmission rate of one minute or less.

Other GADSS 2021 requirements are for the timely recovery of flight data for new aircraft type designs. Flight data recovery could potentially occur in the form of automatically deployable flight data recorders (ADFR) or flight data streaming.

Satellite considerations

An established method to monitor aircraft is automatic dependent surveillance (ADS). Since the aircraft knows its position from its navigation systems, it can transmit this information to the ground. ADS is available in two forms: ADS-B (B for Broadcast) and ADS-C (C for Contract). ADS-B continuously broadcasts unsolicited position and other information, while ADS-C is a requested information exchange via a dedicated ground or satellite link.

ADS-B uses the secondary surveillance radar frequency in the L-Band at 1090Mhz. ADS-C transmissions need to be requested (contracted) through ACARS. ADS-C reporting is established between a specific aircraft and a specific user through a dedicated digital communication link. Requests can specify certain parameters, such as additional information and reporting interval.

Space based ADS-B is the reception of ADS-B broadcasts by satellite. The aircraft will continue to broadcast ADS-B signals normally in the L-Band at 1090Mhz. While the ADS-B specification relies on ground-based networks of ADS-B receivers, new satellite receiver technologies make it possible to track any aircraft within range of a suitably equipped satellite.

Satellite operator Iridium's hosted payload programme did not initially invite many users. Iridium created Aireon, a company that purchased the hosted payload capacity on the new Iridium satellite fleet. The purpose of Aireon is to provide dedicated air traffic surveillance services through space-based ADS-B. Originally developed by Thales Alenia Space Germany of Stuttgart, Germany, high-performance space-based ADS-B receivers as operated by Aireon are primarily geared toward air traffic surveillance for improved air traffic management, but can also satisfy the normal tracking requirement.

In contrast, satellite builder and operator Spire of San Francisco, California and Glasgow, UK has started launching a constellation of hundreds of small, low-orbiting satellites carrying, among other things, comparatively simple ADS-B receivers with a view to offering a space-based ADS-B service as part of their aviation portfolio.

According to Griebel Aerospace Consulting's Hannes Griebel, Ph.D: "The advantage of using ADS-B for tracking purposes is that you do not have to change anything on the aircraft. This is because the aircraft is already equipped with a mandatory ADS-B transponder. The ADS-B position report is broadcast approximately once every second. Even in areas with a lot of interference, this translates to successful tracking update intervals of much less than one minute in most scenarios."

Aireon's approach to the space-based ADS-B solution uses high performance payloads that sift through thousands of transmissions made on the same frequency. Spire's satellites, in contrast, will identify overlapping signals by simultaneously picking up overlapping broadcasts with a large number of receivers. Both systems have passed the proof-of-concept stage, and space-based ADS-B is in now in the evaluation stage, nearing operational approval and introduction.

While Iridium's satellites are all in place by now, Spire is still launching its satellites. Spire's ADS-B system will work globally once the all the satellites are in orbit and the network is complete.

Because ADS-C can use any ACARS link, aircraft have already been routinely connecting with air traffic control via satellite links for decades, in addition to HF or VHF datalinks. Both Iridium and Inmarsat operate satellite data communication networks that offer ACARS and ADS-C services.

The aircraft then sends its tracking information, such as speed and position, down the priority link. Typically, an operator sets up an ADS contract between the aircraft and ATC. Periodically an aircraft in flight will need to cancel a contract, because the aircraft can only have five contracts at a time. On a long-haul flight the aircraft will therefore establish and cancel contracts as it passes through different flight information regions (FIR).

"ADS-B can transmit flight level and

It is an operator's own responsibility to track their aircraft. Aircraft tracking requires a transmition frequency of one minute or less in an abnormal situation.

speed information. However, the system rides on the back of the legacy radar network. There are more parameters with ADS-C. It is possible to know the aircraft's next waypoint, and when it is expected to reach it," says Griebel.

Tamper-proofing

The issue with using ADS-B is that it can be disabled, meaning that the system is not inherently tamper-proof. From a 4D/15 flight tracking perspective, ADS-B solutions will satisfy GADSS. However, because the ADS-B system on board the aircraft can be disabled, it is likely that it will not meet tamper-proof requirements.

One of the leading scenarios for MH370 is that a rogue crew member flew the aircraft deliberately off course. On this assumption, a GADSS system needs to be tamper-proof and able to activate itself. The tracking solutions in operation typically have an overriding feature to allow the crew to manually activate and deactivate them.

The ICAO Committee is debating how to autonomously activate the system.

"The wording around the activation of ADT is relatively vague, and we are debating how to capture the status quo in a document due out later this year," Griebel explains. "What does autonomous mean? Autonomous means that you have a system that cannot be disabled if it catastrophically fails. Pilots and safety regulators can be suspicious when you do not have a circuit-breaker for any electrical circuit on the aircraft."

High-capacity lithium-ion batteries store a lot of energy, and when they fail they can catch fire. Systems that cannot be disabled in flight are not very popular, but if the system can be disabled to isolate a technical malfunction, then it ceases to be tamper-proof.

If it is possible for pilots to manually deactivate the ADT because the system has malfunctioned, then it is conceivable for a person with malicious intent to deactivate the ADT and declare to ATN that the flight is proceeding as normal.

Global communications platform

Global Communications Platform (GCP) is an independent device in terms of power, communications and navigation. It has its own independent GNSS antenna, linkage and power. The device connects to the aircraft power on standby or by the battery bus or the secondary bus. It is possible for the GCP to operate for at least 65 hours without aircraft power in an emergency.

The GCP is a standalone piece of equipment that meets the standards stipulated in the GADSS tracking mandate. The 2021 requirement makes it mandatory for all new aircraft to have an ADT device installed. The GCP correlates to the GADSS requirements, stipulating that operators must be fully responsible for aircraft tracking.

Tracking solutions must meet several criteria listed in ICAO doc 10054 and ED-237, which stipulate that aircraft must transmit aircraft 4D1 requirements during abnormal operations.

According to Satellite Authorisation Systems' managing director, Paul Roux: "Apart from the ADT functions and looking after the recovery of the FDR, we link our system to the 49 bus with a unique symbiotic relationship with the quick access recorder (QAR). We listen to all the information that is being sent from the QAR to the FDR, and use a database to look at the requirements and the minimum upper and lower limits specified in EuroCae ED-237 documentation."

The GCP can send pre- and post-flight information to the airline's control centre via WiFi, satcom or 3G LTE.

Connectivity means the GCP meets the requirement for the ADT device ground-based server to have the ability to collate data. The 429 and 717 bus are the busses that provide the ED-237 data for an ADT based system.

The GCP system links to the FDR wirelessly, where it will monitor ED-237 data as well as the required ADT parameters.

"The biggest concern in the GADSS mandate ICAO AN6 and from ConOps is the independence of the distress tracking unit. There has been a recent consensus to change the tamper-proof wording in the documentation to 'inaccessible'. This is because of concerns raised by flight crews who did not want a tamper-proof system onboard the aircraft," says Roux.

The GCP is installed close to the aircraft's ELT, so it is not accessible by any crew members in flight. From this perspective the GCP solution is unique because it is hard coded and self-powered, and therefore always activated.

Unless an aircraft is in a maintenance check, there is no ability to deactivate the system. When the unit is in a maintenance check it will send a message to the IOCC informing it of its maintenance status.

The GCP is powered by a battery that will exceed both the minimum size requirement of the GADSS mandate and the minimum weight requirement. The unit's battery is self-sustainable. The device is trickle-charged by the aircraft's power and can identify if the aircraft's power is on or off. It will also take preventative measures to continue

It is believed the GADSS system needs to be tamper proof, and has to be able to activate itself.

operation for the duration of the flight. This requirement is aligned to the ELT functionality of 370 minutes. This means any ADT system that is installed on an aircraft will have to remain active for a minimum of 370 minutes.

FDR logs many data sets that are typically looked at when the aircraft has an emergency. The GCP collects pre-determined values and has a sample rate of more than 1,000 per second.

The GCP can monitor 12 different dimensions from an aircraft in flight, as opposed to the four that are required under 4D normal tracking conditions.

Using intelligent algorithms, the GCP can automatically detect when the aircraft's capacity to fly straight and level is impaired or out of sequence relative to ICAO guidelines. These include a set of pre-determined climb, descent and bank angles; these are required because aircraft manufacturers do not disclose the limitations of the airframe and its performance.

Once an aircraft in flight exceeds any of the normal flight standards set by ICAO, the GCP will automatically trigger ADT mode. The system will continue to report in ADT mode until the aircraft resumes a straight and level flight path.

Part of the GADSS ConOps for ADT is the automated start and stop of distress-tracking.

GADSS stipulates that there must be a capacity for the ADT to be activated from the airline on the ground. If the ground operator notices something untoward with the aircraft it will be possible to start ADT transmissions.

GADSS specifies that the source must activate and deactivate ADT. This means that it is only permissible for the airline operational centre that activated ADT manually to deactivate it. If the aircraft triggers ADT mode, only the aircraft can deactivate it.

When an aircraft deviates from its flight plan it is likely that the aircraft will still be flying in a controlled manner, so ADT will not automatically trigger. GADSS stipulates that the airline must be fully responsible for tracking its aircraft.

Therefore, a notable deviation from the aircraft's planned course must be identified by the airline's control centre. If communication is lost, or a sufficient reason for the deviation cannot be articulated from by the flight crew, the airline will manually activate the aircraft's ADT mode.

Teledyne controls

GADSS is not restrictive to airlines, since it is possible for an aircraft to report its position through ACARs every 15 minutes under normal tracking mode.

ACARs has been able to report an aircraft's position for a very long time via ADS. It is possible to send a position report every 15 minutes from the multi-function control and display unit (MCDU) on the flightdeck for future air navigation system (FANS), or via controller pilot datalink communication (CPDLC) equipped aircraft that are flying long-distance oceanic routes, or long overland operations.

It is possible to configure GroundLink Comm+ to collate and report all the information required for the GADSS mandate. The GroundLink Comm+ when connected to an IP satcom system will be able to send a 250-parameter data stream, and to configure the frequency over which the data is sent.

It is also possible for every ACARS message to include the aircraft's position.

According to Teledyne Controls, senior director of aircraft solutions, Murray Skelton: "We can transmit GADSS, ADS and all the ACARS traffic over an I.P. link. Using an ACARS over I.P. link over all the current ACARs links is advantageous because it is secure and fast."

Teledyne Controls developed a system that uses the passenger information and entertainment system (PIES) domain I.P. data source, and links it to the Aircraft Informational Services (AIS) domain. This makes it possible to use an aircraft in-flight entertainment (IFE) I.P. antenna to transmit and receive ACARS and EFB data for operational use.

International Air Transport Association (IATA) and ICAO advisories stipulate that the system must have a minimal performance to use an ACARS network to carry safety related ACARS messages.

Cellular Telephony with I.P VPN security performs a higher level than current HF, VHF or satcom services.

In Europe, US and other regions operators have been granted approval, via a Teledyne special type certificate (STC), to send ACARS information through an aircraft I.P IFE antenna.

Teledyne Controls GroundLink Data Link solution is designed to provide ACARS over IP using cellular connectivity on the ground via the GroundLink Comm+ unit which is already installed on thousands of aircraft. To continue to send and receive ACARS over IP in flight the aircraft has to be equipped with an IP satcom link with internet connectivity.

"Instead of ADT being activated in a distress situation, information will continuously flow to the airline. In addition, the relevant data can be automatically streamed directly to aviation regulators," says Skelton. "There are so many more things that the airline would like to monitor, such as fuel burn, engine core temperature, and many more data sets way beyond those required for GADSS."

Information is transmitted through inexpensive channels, so much more data can be sent in real time from that aircraft. Furthermore, GroundLink Data Link+ will reduce the ACARS usage cost,

The Teledyne GroundLink Comm+ can collate and report all the information required to satisfy the GADSS tracking mandate.

because the system transmits data via the IFE system. Typically, IFE data is pre-paid in the terms of (gigabyte) GB usage.

Companies such as Inmarsat are developing business cases to lower the cost of in-flight broadband usage to make it more viable for the complete connected aircraft.

The ADS-B transponder can be used for ADT, although the system must be in range of a ground signal or satellite, depending on the aircraft's connectivity system.

All aircraft transmit an individual four digit transponder code that is called a SQUAWK code. The unique code is assigned by ATC and enables them to identify the aircraft. In an emergency it is normal for flight crew to change the aircraft's SQUAWK code to a distress setting, in order to inform ATC of the emergency.

If the captain sets the aircraft's transponder to an emergency SQUAWK setting, then ACARS will transmit additional GADSS tracking data. The aircraft must be in ACARS range, which is not always possible, even if the aircraft has satcom and HF. This is because there are parts of the world where ACARS will not operate and there is no satellite coverage. Subsequently there is not always a guarantee the ADT information transmitted will be received.

L-Band does not have complete global coverage. There is no system that is 100% infallible. However, the system that has come closest to global coverage is the Iridium satcom network.

Many airlines use the Iridium network because they know that wherever they are in the world their aircraft will always have voice or data communication. However, data capacity across the Iridium network can be small.

In many cases a lot of the IFE satcom providers have good global coverage. There is a new generation of satcom services being introduced, yet it will take time before there are enough satellites online for complete global coverage.

It is not possible to use distress-tracking everywhere, because there are holes in the satellite coverage.

Teledyne Controls' Next Gen system will have the capability for the airline to set a range of parameters that under certain conditions trigger data sets for distress and abnormal tracking and also stream additional aircraft systems monitoring data.

"If there is a cabin pressure anomaly and the cabin pressure has dropped below an acceptable level, then this will trigger an emergency data set to be sent to a specialist within the airline. It is also possible to send the data directly to the original equipment manufacturer (OEM) so that it too can monitor the symptoms," says Skelton.

The ground-based specialist can decide if the aircraft continues its flight or lands at the earliest opportunity. The system will also automatically trigger the distress-tracking mode function.

Access to the flight plan data makes it possible to know if the aircraft is deviating off course. This is as well as the distress function being activated by ACARS. The system will then alert the relevant airline departments and aviation authorities.

"There are no switches on the flightdeck that can activate or deactivate the GroundLink Comm+. It is an autonomous unit that is designed for collecting, processing and delivering data. It will do this in accordance to the rules it has been given," says Skelton. "It is not possible to data-load the system in flight to corrupt its operation. The system can only be data-loaded and reconfigured when the aircraft is on the ground. Once the aircraft is in the air it will fulfil the preloaded requirements of its configuration."

In flight it is possible to ask the unit to send specified data sets, and to set codes. The Next Generation unit can send detailed reports when requested.

FDR recovery

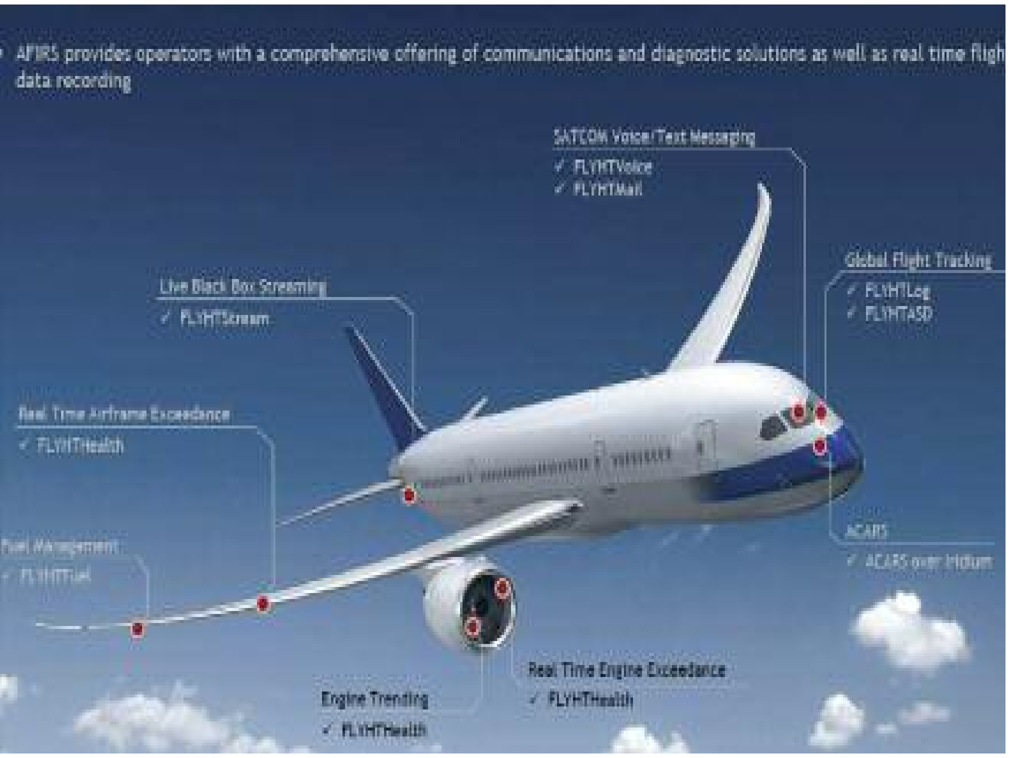
ARINC 717 is a standard for the data parameters that are sent from the acquisition unit to the FDR. Airlines can add more parameters to the 717 data set for specific monitoring. Some airlines regularly monitor the 717 data stream because they want to observe procedures, such as auxiliary power unit (APU) on and off times. This is useful, because they do not want crews to over-use the APU while on the ground to prevent fuel wastage.

The frame speed is the rate the data is recording in words per minute. An aircraft's frame speed increases as aircraft become more parameter-rich.

"Frame rates can be 256 words per minute to 512, to 1,024 words per minute. Frame rate relates to the samples the aircraft is taking per minute. Improving the frame per minute rate improves the granularity of the data recorded," says Skelton. "If you start streaming 717 data from the moment the aircraft leaves the ground to when it lands, at a frame rate of 512 words per minute, it will have recorded 1 megabyte (MB) of data per flight hour."

This means that transmitting full 717 data across a satcom network can be expensive.

Currently, the data has to be recovered manually from QARs or via cellular radio transmission on the ground at the end of a flight using a wireless quick access record (WQAR) like the GroundLink Comm+.However as data costs reduce for satcom services the business case for airlines to stream the full 717 data in flight becomes more attractive. Obviously the implications for both safety and operational



It is possible that operators will want to retrofit legacy aircraft to GADSS 2021 standards for commonality purposes.

improvements increase with a live data stream from the aircraft.

"Looking at other data types on the aircraft, the CVR data is another data source that could be streamed but good quality sound is needed for this, as you are not just listening to the pilots' voices. Background noises need to be recorded and analysed in the event of an accident. But there is no reason why CVR data and cabin surveillance data cannot be delivered by the same IP links," says Skelton.

The next generation of GroundLink will be able to trigger and activate airline defined data sets compressing and sending the data to ground systems both airline, OEM and regulatory via a secure I.P. VPN potentially adding and enhancing the mandatory GADSS distress packet set. In the future, using secure IP links and systems like the GroundLink will mean that all aircraft data, including voice and video, could be delivered in real time as a continuous data stream from the aircraft.

FLYHT

The GADSS autonomous distress tracking mandate is associated with new aircraft entering service in 2021. OEMs have indicated that they have selected the technology to meet the GADSS 2021 tracking mandate.

According to FLYHT, manager of products, Matt deRis: "Because Boeing and Airbus have chosen a different technology path forward for ADT solutions, we stepped away from satisfying the mandate directly, and are focusing on retrofit solutions."

FLYHT's Automatic Flight Information Recording System (AFIRS) product interfaces with a customizable variety of aircraft databuses in addition to being able to monitor the output to the flight data recorder similar to standalone QAR. It is possible to remotely upload ADT compliant 4D tracking and distress monitoring algorithms to aircraft that already have an AFIRS unit installed. To achieve full compliance, the AFIRS system on the subject aircraft must already be connected to the appropriate databuses to trigger the ADT function, for example those containing pitch-and-roll parameters.

"For the retrofit market, if a customer would like to achieve the same capability from GADSS, there are existing units that FLYHT produces that can better flight-track an aircraft than the current ADS-B requirement," says deRis. "It is possible to configure the AFIRS unit to record and transmit GADSS ADT information. The number of recordable parameters depends on the age of the airframe and the number of databuses available. AFIRS can use data from ARINC 429 standard and ARINC 717 standard buses."

AFIRS can simultaneously monitor databuses by a variety of custom-written algorithms. The standard unit offering includes satcom, allowing real-time global coverage, meaning it can send information to a flight operation centre.

AFIRS 228S provides complete aircraft visibility that will yield aircraft management information. The AFIRS is installed in the avionics bay and can monitor engines, avionics and navigation systems, or anything with a standardized output. This flight data is automatically transmitted over the Iridium network to servers on the ground that forward the information to the flight operations centre.

In the event of an alert onboard, the aircraft notifications are automatically sent to all applicable personnel. Notifications can be e-mail alerts to mobile phones or PDAs. Engine Condition Trend Monitoring (ECTM) will monitor the aircraft's engines. The system monitors the engines for damage, deterioration and excessive wear.

AFIRS records and transmits real-time flight data enhancing flight operations quality assurance (FOQA) datasets. In the event of an in-flight emergency, AFIRS will transmit FDR data in real time over Iridium.

Most satcoms have a variety of ARINC 429 inputs, a processing unit and the ability to host additional software. "We have taken the step to incorporate a downlink capability within the hosting function, so it is effectively hosted on a satcom. This is to enable the satcom to move the data from the aircraft and send it to the airline over I.P.," says deRis. "Real-time aircraft health monitoring is possible as well, enabling airlines to perform dynamic cost indexing. The system can take information from the flight management system (FMS) as long as there is the appropriate output from the system."

It is also possible to set AFIRS parameters to increase the aircraft tracking rate and send alerts to the airline in the event that the aircraft deviates from its flight plan.

Currently, this capability is manually activated and deactivated; however, with the inclusion of the distress monitoring algorithms, it can be automated. Power schemes are being evaluated to notify the airline should a tamper situation occur.

Data recovery

The FLYHT stream service has the capability to recover FDR information. Once activated, FLYHT increases the number of reports and streams the FDR data to an airline. The ground system will collect the data and make it available through a user interface.

"If you trigger the FDR streaming because of a certain event, then you will get the data stream pertaining to that event. This data will be used as a back-up to the FDR," says deRis. "Yet streamed

The ADFR deploys when the aircraft enters and unusual attitude. The units floats on the water and transmnits its location.

FDR data may not necessarily capture all the information from the start of the flight up to the point that the accident took place. We are in the process of developing new hardware products to fill a gap between the time before FDR recovery and the event."

The Iridium network can stream data at a maximum rate of 2.4 kilobytes (Kb) per second. It is possible to stream live FDR in flight or by sending packets of information during an emergency situation event. Streaming historical data is challenging because a large amount of data needs to be sent in a short period of time.

The FDR will record all the required datasets from the beginning to the end of flight. In an emergency the FLYHT solution makes it possible for the system to backdate and off-load a significant portion of the FDR data. This download data could include all FDR data sets for the 20 minutes before the end of the flight.

"Because timely recovery of flight data (TRFD) and ADT is not mandated for all aircraft and is only required for new aircraft, airlines are reluctant to invest in systems and procedures that would be applicable for their entire fleet," says deRis. "If TRFD becomes compulsory for current fleet types, then retrofit solutions that encompass the recovery of all data will gain traction, because the airline must make the investment."

There is an economic issue for airlines to stream this data. The technology is available, but the business case for steaming FDR data will become more attractive to airlines when available bandwidth increases and satellite communication service providers improve per-byte-prices.

"Based on recent events pertaining to FDR recovery, there is a growing sentiment that the technology exists now, and that there is less and less reason why we should not retrofit all existing aircraft with the capability for FDR recovery," says deRis.

It is forecast that more airlines will want to retrofit their legacy aircraft to GADSS 2021 standards for commonality purposes. This is because airlines will want to narrow the technology gap between new forward-fitted GADSS-compliant types and older aircraft.

Deployable FDR

Applications for new aircraft designs must have a capability to retrieve FDR data as part of a GADSS requirement pertaining to PFLR. If an OEM applies for a new type certificate after January 2021, then it must to adhere to FDR recovery regulations.

One prominent idea is for OEMs to deploy the FDR memory modules from the aircraft. In a runaway distress situation, the automatically deployable flight recorder (ADFR) deploys from the aircraft at the point of impact or immersion in water. Once deployed, the ADFR will float on the ocean, transmitting its location until it is recovered.

Search and Rescue (SAR) authorities, globally, have been routinely recovering deployable recorders from military aircraft since the early 1960s with high success. The ADFR's emergency locator transmitter (ELT) is integrated with the CVR-FDR memory.

There is a near perfect record of recovery of this product with (military) transport aircraft types.

History has demonstrated the reliability of deployable recorders in land and water incidents from military aircraft. Since starting to keep records in 1967, Leonardo DRS deployable recorders have been involved in 25 CAT 'A' transport aircraft events. In one event the deployable did not deploy due to improper installation by maintenance personnel.

The ADFR is designed and tested to extremely onerous crash requirements to ensure post-event survivability.

The ADFR's ELT is equipped to provide a minimum of 150 hours of 121.5MHz homing. This extended duration is to ensure that the ADFR is easily recoverable in periods of bad weather or high sea-state. No special equipment or processes are required to locate and recover an ADFR in oceanic regions. For on-land events, the ADFR is equally recoverable and survivable.

One of the benefits of a deployable recorder is that no new technologies are required to support search and recovery. The deployable recorder contains an integrated dual-frequency ELT that transmits a GNSS-enabled 406 MHz distress frequency, and a 121 MHz homing frequency. The GNSS-enabled 406 MHz distress frequency (post-deployment) can be tracked by the COSPAS-SARSAT satellite system to within a radius of 10 metres.

The 121.5 MHz frequency is the ubiquitous global standard for SAR Homing and can be used by aircraft or ships, including non-SAR assets, to Home and locate the deployed ADFR unit. Because the system relies on the proven COSPAS-SARSAT global SAR infrastructure, no new policy or practices are required to locate and retrieve an ADFR from water or land.

The ADFR intends to provide position updates throughout the (in-fight) distress event (this capability in-flight is not confirmed yet); and at the location of the point of end-of-flight. Once deployed, the ADFR continues to provide GNSS-enabled ELT transmissions, along with the 121.5 MHz Homing frequency.

The deployable FDR with its integral ELT helps a SAR Agency to confirm the 'Location of End of Flight,' thereby improving response time to the accident

Aircraft can fly a long distance and cover a large area in one minute's flying time. Transmitting tracking information at one minute intervals still means an aircraft in distress can be in an area the size of London.

site. Having both the location of the end of flight and subsequent position 'updates' as the ADFR 'drifts' at sea substantially improves the probability of locating survivors, aircraft wreckage and the ADFR in a timely manner. An ADFR can minimise the search phase of a SAR event, and allow authorities to focus on rescue and recovery.

It is still required to install one fixed combination recorder (CVDR) in the aircraft. The L3Harris Technologies CVDR is part of the ADFR system.

The L3Harris/Leonardo DRS cockpit voice data recorder (CVDR) system achieves this requirement by installing a fixed combination-recorder in the forward avionics bay, and a deployable combination-recorder in vertical tail plane (VTP).

Each unit records all of the voice and flight data, ensuring that in any accident situation the recovery of at least one recorder will provide all required data to the accident investigation authorities.

Airbus' safety requirements for non-commanded deployment ensure an extremely robust safety factor during flight. There are no known reports of a deployable FDR in military service causing injury or damage.

The international aviation community has worked under the leadership of EUROCAE to develop and issue the minimum operational performance specification (MOPS) for flight recorders (ED-112A). This document sets out the requirements for operational performance of all flight recorders including ADFRs.

An ADFR installation is similar in weight to a fixed recorder and ELT-Automatic Fixed (ELT-AF). There is no weight delta associated with the installation of an ADFR if that device also replaces a separate ELT. The ADFR does not place additional maintenance burden on the aircraft.

Unlike telemetry systems relying on either Inmarsat or Iridium, ADFRs make use of the international COSPAS-SARSAT satellite constellation comprising the LEO, GEO and MEO star satellites ensuring robust 100% global coverage with a single satellite network.

ADFRs have the ability to continue to record flight data throughout the distress phase including during rapid changes in flight altitude. Telemetry connections can be compromised with rapid changes in flight pitch and altitude. ADFR ELT increases the ability for search and rescue teams to rapidly locate potential survivors of downed aircraft, particularly over water.

COSPAS-SARSAT is a multi-government funding global SAR service, free to all users of an ADFR. When telemetry data is unavailable, the ability of a deployable recorder to float on water eliminates the large cost of an underwater search for the black box and provides quick access to critical CVR/FDR data post-event.

Like all flight recorders, an ADFR is subject to the periodic data read-out of the memory in accordance with national airspace regulation.

An ADFR has similar scheduled maintenance to that of a fixed recorder and ELT-AF. A fixed recorder and ELT-AF, each need to have their respective battery's replaced on a five-year schedule. The ADFR has one battery for the ELT, which is replaced on a five-year schedule.

In addition, data can be retrieved and updated via the Recorder Interface Unit (RIU), which allows easy access to maintenance personnel. Again, no additional maintenance action is needed, because it is the same accessing the deployable recorder in the aft position.

Airbus is focusing on a line-fit deployable recorder solution for its commercial airliner programmes.

Conclusion

For airlines it is not just the effective date of the GADSS mandate that is important. One of the biggest concerns for airlines is the uncertainty of the available systems. Airlines are worried because the stricter the mandate, the more it will cost to make fleets compliant.

Airlines such as Hawaiian Airlines are progressive in their approach. They are already coming up with ideas on how to implement GADSS. Other airlines are researching viable options. Yet some airlines want to avoid it all together.

Aircraft flying in European and North American airspace will be tracked by ATC. Airlines operating over these regions will not be required to make changes to their legacy fleets, and can rely on comprehensive network coverage offered by ATC. Tracking aircraft is important when they enter oceanic airspace.

AF447 was transmitting a position fix every 10 minutes before it crashed, and it took two years to locate the wreckage. An aircraft in a gradual descent is capable of travelling a great distance in one minute. Tracking even at one-minute intervals could mean a SAR area almost the size of London.

There are places in the world where aircraft can disappear. Because gaps in the satellite network are typically not greater than seven minutes' flight time, it is still possible to meet the normal mandatory flight tracking requirement by sending a position report every 15 minutes.

When technology advances and more satellites are online, it is likely that both normal tracking and ADT transmission frequency will be increased. AC