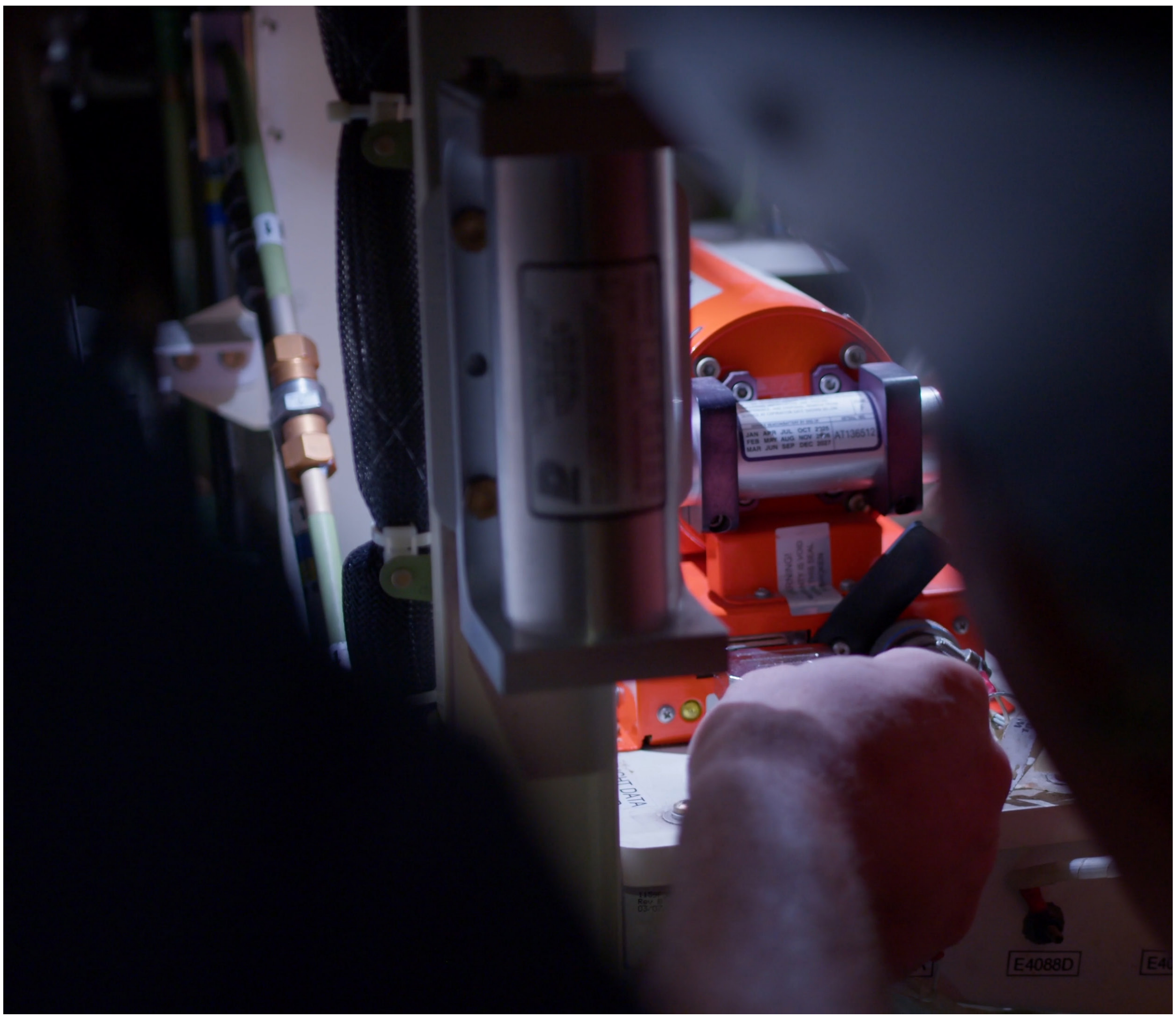
Publication of Duncan Aviation

STRAIGHT TALK ABOUT FDRs/CVRs

Contributions by Matt Nelson & Mark Winter



www.DuncanAviation.aero/straighttalk

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EDITOR'S NOTE

Why We Publish Straight Talk Books
Thank you for reading our *Straight Talk* publication regarding Flight Data and Cockpit Voice Recording, and also for the other NextGen (Next Generation) technologies. For instance, we've published updated information regarding FANS/Datalink in our *Straight Talk About Datalink (ACARS, FANS 1/A+ & ATN)*: *www.DuncanAviation.aero/resources/straight-talk/datalink*.

This guide is intended to be a learning tool, and we attempt to answer all of your questions regarding FDRs (Flight Data Recorders), CVRs (Cockpit Voice Recorders), and their regulations. If we inspire more questions and discussion surrounding these technologies, please send us a note with a question or comment on our Straight Talk resource page: *www.DuncanAviation.aero/resources/straight-talk.*

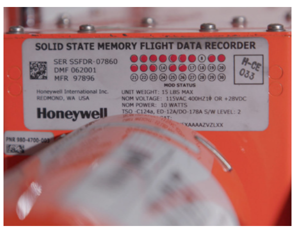
At Duncan Aviation, we're on the cutting-edge of avionics technology, and it's no different with FDRs. We understand the regulations, trust our OEM partners, and know the equipment that is currently available. Additionally, over the past two decades, we have talked with hundreds of our customers and manufacturers so we can provide the most useful and comprehensive information available for our customers with regard to recorders and the other NextGen mandates.

As always, we strive to improve ourselves and our knowledge. Feel free to contact our avionics experts with any of your concerns, questions, or challenges. See page 8 for names and contact information or visit our website: *www.DuncanAviation.aero*.

Duncan Aviation Avionics Teams

NEXTGEN INITIATIVES & FLIGHT/ COCKPIT DATA RECORDERS

For the past several years, Duncan Aviation has written articles, posted blogs, and held seminars about the FAA's initiative for the future of national airspace management and control called Next Generation Air Transportation System or NextGen. We've found that nearly everyone has heard about the NextGen initiatives, but we have found that no one seems to have a firm grasp on the rarely-spoken-about subject of FDRs and CVRs. Even less is understood about how they fit into the NextGen puzzle.



When one thinks about the term NextGen, the first thing that usually comes to mind are the worldwide mandates surrounding ADS-B. Concurrently, there were and are several worldwide requirements developed for digital datalink communications, such as FANS-1/A. The advent of digital communications aboard aircraft presented a problem that a traditional CVR could not fix. How do you record digital communications? CVRs were then developed to meet the newer regulations that include recording digital communications data and increasing the recording time from 30 to 120 minutes. The increased storage capacity is mainly due to solid-state media inside the recorder.

Along with the development of digital storage media for recording devices came the development of new and more capable FDR devices that record more data points in the aircraft for longer periods of time. These data points are known as parameters. We'll explain a lot about different parameters and the regulatory environment surrounding them in the coming pages.

THE ORIGINS OF FLIGHT DATA & COCKPIT VOICE RECORDING

As with a lot of innovation, FDRs and CVRs were borne from disaster. We needed a way to learn more about aircraft incidents and accidents and the events leading up to them. The first generations of recorders were introduced in the 1950s and were constructed of materials and designs that allowed them to (hopefully) remain intact in the event of an accident. Additionally, part of that survivability equation required them to be painted either bright orange or bright yellow and to be installed as far aft in the aircraft as practicable. Interestingly, despite their bright colors, recorders were referred to as the infamous black boxes. Both FDRs and CVRs are fit with an Underwater Locator Beacon, which is a device solidly mounted to the recorder that begins emitting a signal when it becomes submerged in the water. These features allow the recorder to be found more easily in the event of an accident in or near a body of water.

Over the years, various generations of recorders were developed with greater capabilities and more reliable construction. Most of these upgrades were in response to advances in the technology used for the construction of aircraft components, but also to the number and types of parameters they were being asked to record. Various regulatory agencies all over the world began requiring CVRs and FDRs in certain types of aircraft with the ability to record certain numbers of parameters. Eventually, ICAO (International Civil Aviation Organization) put together a working group to develop technical and operational provisions related to flight recorders, which have been responsible for several amendments to Annex 6, Operation of Aircraft.

As previously discussed, FDRs have been improved upon and redeveloped in various ways to record more information for longer periods of time. FDR makers must manufacture these products to a certain standard for obvious reasons, and the standard and its subsequent versions are TSO-C124(x). The TSO for CVRs is TSO-C123(x).

FLIGHT DATA RECORDER OPERATIONS

For the purposes of this publication, we will focus on the newer generations of recorders and will refer to them by their acronyms. The latest versions of the FDRs are called DFDRs (Digital Flight Data Recorders), and Cockpit Voice Recorders are the same as before: CVRs.

The DFDR is physically wired to various systems in the aircraft to provide investigators with a clearer picture of the flight circumstances in the time leading up to an incident or accident. The most basic of those systems recorded included time, airspeed, altitude, magnetic heading, vertical acceleration, pitch attitude, roll attitude, and many others. As DFDRs became more capable, the number of parameters they measured were limited by the physical connections required to connect them to all of the sensors and equipment in the aircraft. This is when the FDAU (Flight Data Acquisition Unit) and the DFDAU (Digital Flight Data Acquisition Unit) came into being. The FDAU/DFDAU is a separate component installed in tandem with the FDR/DFDR and is used as a sort of analog-to-digital converter that collects analog signals from aircraft systems and converts them into a digital format to be transmitted to the DFDR. The use of a FDAU/DFDAU greatly expanded the capacity of the recording devices.

Later generations of DFDRs and CVRs combined the units into a single recorder, known as a CVFDR (Cockpit Voice Flight Data Recorder). As a result of combining systems, recorders were ultra-capable, very small, and required even less aircraft power to operate. That combination of attributes has now allowed fully-capable recorders to be installed in smaller aircraft and in the emerging AAM (Advanced Air Mobility) industry.

As the acronym describes, the CVR is designed to record all sounds in the cockpit during flight. The CVR is physically connected to all of the microphones and headsets for each pilot and/or observer on the flight deck. In addition to physical connections, an area microphone hard-mounted on the flight deck picks up voice commands, noises from the speakers, aural warnings, and casual conversation among the crew. As mentioned in the NextGen Initiatives section, the latest versions of CVRs meet regulations for longer recording times and record the digital data transmitted from the aircraft as a part of a FANS-1/A system or something similar.

Since the early 2000s, there has been a lively debate between the aviation industry and pilots' organizations concerning CVRs (Cockpit Digital Video Recording Systems). Regulatory agencies worldwide and many advocacy groups see a need for a video recording system in the flight deck. Pilots' organizations oppose them for fairly obvious reasons as well. The debate has reached a stalemate. Video recording systems have been used in military applications for many years, and the lessons learned from those recordings are somewhat cloudy. There may be some valuable lessons and graphic evidence gleaned, simply because a picture is worth a thousand words.

Some regulators believe that if used properly, CVRs could replace some parameters that are difficult for DFDRs to record in older aircraft. At this time, it's just speculation, and we'll talk more about this later in the book.

We've mentioned the word *parameter* which is, as it relates to FDRs, a measurable flight characteristic produced by one or more systems onboard an aircraft. There are usually at least 88 parameters that most regulatory agencies require to be recorded in the latest aircraft models. Incidentally, as aircraft replace older analog systems with digital systems and controls, it is likely that this list will expand.

REGULATIONS REGARDING FDR/CVR INSTALLATION

The regulations covering an aircraft depend on the country in which the aircraft is registered. For aircraft registered in the domestic United States, you need to know under which FAR Part the aircraft was certified (Part 23, 25, 27, 29, etc.), the date of manufacture, date of type certification, and under which FAR Part the aircraft will be operating (Part 91, 135, etc.). You'll also need to know the number of certified passenger seats onboard, the number of engines on the aircraft, and the gross takeoff weight of the aircraft.

Please refer to the FAA's AC 20-186 Appendix A, AC 20-141B Appendix 3, FAR Part 91.609, and FAR Parts 135.151 and 135.152 for more information.

Due to the number of variables involved in the regulations concerning CVR and FDR equipment, we'll focus here on the following aircraft:

- Those manufactured under Part 25
- operating under either Part 91 or Part 135,
- with 9-or-fewer passenger seats
- or 10-or-more passenger seats

Even Part 91 aircraft operating under Subpart k are covered under Part 135 rules in terms of FDR equipment.

Basically, a CVR is required for all Part 25 aircraft operating under Part 91 and 135. Aircraft manufactured after April 6, 2010, are required to have a 2-hour CVR; aircraft manufactured prior to that date must have a 30-minute CVR. If the aircraft is operating under Part 135 and has 10-or-more passenger seats, it must have a 2-hour recorder regardless of when it was manufactured. Both 91 and 135 aircraft are required to have datalink recording capabilities depending on their date of manufacture and whether a datalink system is installed.

FDR regulations are more complex.

- Part 25 aircraft operating under Part 91 that were manufactured after October 11, 1991, and have 10-or-more passenger seats, must have an FDR that records 18 parameters
- Part 25 aircraft operating under Part 135 that were manufactured after August 19, 2002, and have 10-30 passenger seats, must have an FDR that records 88 parameters
- Part 25 aircraft operating under Part 135 that were manufactured between August 18, 2000, and August 19, 2002, and have 10-30 passenger seats, must have an FDR that records 57 parameters
- Part 25 aircraft operating under Part 135 that were registered after October 11, 1991, and have 10-19 passenger seats, must be fit with an FDR capable of recording 18 parameters
- Part 25 aircraft operating under Part 135 that were manufactured after October 11, 1991, and have 20-30 passenger seats, must have an FDR capable of recording 29 + 17 optional parameters
- Part 25 aircraft operating under Part 135 that were manufactured before October 11, 1991, and type certificated after September 30, 1969, must be fit with an FDR that records 22 parameters

Clear as mud? It may help to reference the flow chart in AC 20-141B Appendix 3: *www.faa.gov/documentLibrary/media/Advisory_Circular/AC_20-141B.pdf*

REQUIREMENTS FOR MEXICAN AIRSPACE

In part, we created this book as a result of the expanded FDR regulations required by AFAC (Agencia Federal de Aviacion Civil), or the Mexican aviation authority, formerly known as the DGCA. Although regulations were imposed more than 10 years ago, the mandate deadlines are approaching and enforcement of those regulations is beginning. There have been many articles written describing some of these requirements, and just as many describing the *enforcement* part of the discussion. However, there is even more nuance to the regulation and its enforcement.

What we understand from the regulations, and the regulators and operators we regularly work with, is that once an aircraft lands in Mexico and is subjected to a ramp check, the regulations regarding expanded FDR parameters apply. One requirement stipulates that an aircraft be equipped with an FDR installed in accordance with the appropriate regulations of the country in which the aircraft is registered. However, if that aircraft is operating in Mexico, it is required to be equipped with an FDR under Mexican regulation.

The term *operating* is a little ambiguous and seems to apply to an aircraft that flies one or more legs in Mexican airspace. For example, if an N-registered aircraft holds a flight plan to fly from Houston, Texas, to Toluca, Mexico, and directly back to Houston, the aircraft will be required to have an FDR installed in accordance with FAA regulations. If that same aircraft holds a flight plan to fly from Houston to Toluca and then on to Veracruz, the aircraft must be equipped with an FDR that complies with Mexican regulations. As a result of this requirement, most aircraft that travel frequently into Mexican airspace must be equipped with an FDR that complies with Mexican (AFAC) regulations.

Before we get to the regulations, there are four types of FDRs installed in fixed-wing aircraft:

- Type I and IA FDRs must record the necessary parameters to accurately determine the flight path, speed, attitude, power or thrust of the engines, configuration, and operation of a fixed-wing aircraft
- Type II and IIA FDRs must record the necessary parameters to accurately determine the flight path, speed, attitude, power or thrust of the engines, configuration of the lift devices, and aerodynamic resistance of a fixed-wing aircraft
- Types I, IA, and II FDRs must keep the information registered during the last 25 hours of operation; Type IIA FDRs must keep the information recorded during the last 30 minutes of operation
- Type I FDR must be capable of recording, depending on the type of fixed-wing aircraft, the first 32 parameters indicated in Regulatory Appendix A Table 1 of the Official Mexican Standard
- Type IA FDR must be capable of recording, depending on

the type of fixed-wing aircraft, the 78 parameters indicated in Regulatory Appendix A Table 1 of the Official Mexican Standard
- Types II and IIA FDRs must be capable of recording, depending on the type of fixed-wing aircraft, the first 16 parameters indicated in Regulatory Appendix A Table 1 of the Official Mexican Standard. Type IIA FDRs, in addition to recording the last 30 minutes, must also retain sufficient information from the preceding takeoff for calibration purposes

The Mexican FDR regulation for equipage can be summed up as follows:
- **Type II FDR**—required by fixed-wing turbine aircraft that were type certificated on or after January 1, 2016, that have 10 or more passenger seats or maximum take-off weight greater than 5,700kg
- **Type IA FDR**—required by fixed-wing aircraft that were type certificated on or after January 1, 2005, that have 10 or more passenger seats or with a maximum take-off weight greater than 5,700kg
- **Type IIA FDR**—required by fixed-wing turbine aircraft that were type certificated on or after January 1, 1990, that have a configuration of nine or fewer passenger seats or with a maximum take-off weight equal to or less than 5,700kg
- Fixed-wing turbine aircraft type certificated on or after January 1, 1989:
    - **Type I FDR**—All fixed-wing aircraft with a maximum certificated takeoff weight greater than 27,000kg
    - **Type II FDR**—All fixed-wing aircraft that have 10 or more passenger seats or with a maximum take-off weight of 5,700kg and up to and including 27,000kg of maximum take-off weight
- Fixed-wing turbine aircraft that were type certificated on or after January 1, 1987, but before January 1, 1989, that have 10 or more passenger seats or with a maximum certified takeoff weight of 5,700kg must be equipped with an FDR that records: time or time reference, altitude, airspeed, normal acceleration, heading, and other parameters necessary to determine pitch attitude, roll attitude, radio transmission control, and power or thrust of each engine
- Fixed-wing turbine aircraft that were type certificated before January 1, 1987, that have 10 or more passenger seats or with a maximum take-off weight of 5,700kg must be equipped with an FDR that records: time or time reference, altitude, airspeed, normal acceleration, and heading
- Fixed-wing turbine aircraft that were type certificated after September 30, 1969, and have a maximum take-off weight greater than 27,000kg must be equipped with an FDR that registers, in addition to the time or time reference, altitude, airspeed, normal acceleration and heading,

as well as the additional parameters that are necessary to meet the objectives to determine:
- o The attitude of the aircraft upon reaching its flight path, and
- o The basic forces acting on the aircraft leading to the achieved flight path and the origin of such forces

- **Type II FDR**—required by fixed-wing turbine aircraft that have a maximum take-off weight greater than 27,000kg type certificated after September 30, 1969

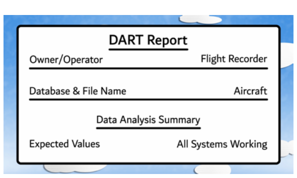
THE COLLECTED DATA

Data recorded by DFDRs/CVRs is sometimes used to aid the authorities who are investigating an incident or accident. There are many other uses for the data, but it must be downloaded and either interpreted or correlated to their normal operating range.

Specialized test equipment is physically connected to the recorder to download the data. The data is then sent to a third-party that interprets and analyzes the data and monitors the integrity of the system.

The analysis shows whether the recorded parameters are within the tolerance under which they normally operate. Or to say it another way, the analysis ensures the aircraft systems are operating properly and not supplying inaccurate data. Techs can also interpret the data to help troubleshoot a system that may not be operating properly.

Downloading data from an FDR or CVR usually requires a specialized piece of equipment that physically connects to the recorder. Once the raw data is extracted, it can be sent to a number of vendors, including aircraft OEMs, to validate it and test it for integrity. This step determines if the parameters being recorded meet specifications.



In some applications and configurations, aircraft can be equipped with what is known as a QAR (Quick-Access Recorder). A QAR is a piece of permanently-installed equipment that's physically attached to an FDR. It provides the operator with an abbreviated subset of the recorded data in order to comply with some aircraft operators' SMS (Safety Management System) or insurance carrier regulations.

An SMS is a formal system of risk management procedures used by an organization to mitigate risk, report and review incidents, and

correct issues that affect safety. Currently in the US, the FAA's SMS program for aviation companies and organizations is voluntary, but countries under the EASA (European Union Aviation Safety Agency) umbrella require aviation companies to have an SMS in place.

A company's flight department, for example, will use an SMS to identify areas of risk within that flight department and mitigate them to the point at which those risks are acceptable. A significant part of the data used to identify some of these risks comes straight from the aircraft itself in the form of operating parameters recorded by the FDR and/or CVR. Typically, the data is downloaded from the recorders on a schedule and analyzed for integrity, just like any other form of preventive maintenance. This is still a voluntary program for US-based flight departments and 145 repair stations, but it will likely become mandatory in the next several years.

Although voluntary in the United States, Duncan Aviation's Flight Department implemented its SMS in 2011, and the rest of the company began implementing an SMS in 2013.

The sub-set of data downloaded from an FDR and used as a part of an overall SMS strategy in a flight department is called FOQA (Flight Operations Quality Assurance) or FDM (Flight Data Monitoring). FOQA and FDM are an element of an Annex 6 ICAO (International Civil Aviation Organization) mandate that says commercial airlines must adopt a FOQA/FDM program under regional regulation. EASA and other aviation regulatory agencies around the world adopted the mandate of FOQA/FDM. The FAA, in Advisory Circular AC 120-82, defines FOQA and states that it will remain a voluntary program in the United States. Based on our experience and news reports from regulatory agencies, when aviation regulatory agencies around the world adopt mandates, the FAA usually adopts them a few years later.

FAQs

Is there a reason to have both recorders (FDR/CVR)?
Absolutely. According to the flow charts contained in Advisory Circulars AC 20-141b and AC 20-186, there are several classes of aircraft that require both a CVR and an FDR.

Does my existing FDR/CVR meet the current requirements?
Take a look at the regulations of the country under which your aircraft will be registered to determine which regulations you must comply with.

NOTE: At the time of this writing, the FAA and NTSB are proposing new rules that will increase requirements for a CVR from the current 2 hours of audio and data to 25 hours. This will likely be a forward-fit mandate, requiring certain aircraft to retrofit as well.

What equipment does my helicopter, rotorcraft, eVTOL or UAV require?
At the time of this writing, there are no regulations requiring eVTOL (Electronic Vertical Talk Off & Landing Vehicles), UAM (Urban Air Mobility/Advanced Air Mobility), or UAV (Unmanned Aerial Vehicle) aircraft to carry a Flight Data Recorder onboard the aircraft.

What's the cost of installation?
Costs for the equipment and certification paths differ based on an aircraft's current avionics configuration. It will cost more to retrofit an aircraft that is currently equipped with all analog devices than one equipped with mostly digital devices. Please call one of Duncan Aviation's knowledgeable Avionics Sales representatives (*www.DuncanAviation.aero/services/avionics-installation/contacts*) for more information on costs.

How much downtime is needed for the installation?
The physical installation is an involved, invasive project, as it will likely touch nearly every system in the aircraft depending on the number of parameters required. You might budget for a minimum of two weeks downtime.

Are certification requirements and costs a part of the upgrade?
Usually, yes. The certification path for an FDR installation or upgrade must be performed with an STC (Supplemental Type Certificate). The costs are normally built into the installation proposal if an STC exists. If your proposal does not specify the certification path, ask about that. FDR

installations cannot be approved or returned to service via FAA Field Approval because of the invasive and technical nature of the installation. Doing so will likely result in getting flagged by an aviation authority. If there is not currently an STC available for your make/model, it can be certified as a one-time STC, which is expensive and time-consuming.

As a prospective buyer, what do I look for?
In terms of FDR/CVRs, compare the regulations of the country under which the aircraft will be registered to the equipment installed in the aircraft. Having an FDR or CVR in the aircraft does not mean it meets the requirements of the country of registration. Typically for an FDR, look at the year the aircraft was manufactured, the GTOW (gross takeoff weight), the number of certified passenger seats, and the number of parameters being recorded, and then compare those to the regulation. You can normally locate the number of parameters being recorded in the AFMS (Approved Flight Manual Supplement) generated by the original installation. For an existing CVR, check the recording length, comparing that to the regulations. In addition, both recorders (or a single in the case of a CVFDR) will have a ULB (Underwater Locater Beacon) attached to them. The service life of the battery and the date of manufacture and expiration date for the ULB(s) are important information.

What role do aircraft OEMs play?
OEMs typically develop forward-fit solutions for the aircraft they're currently manufacturing. Most regulations begin with a forward-fit requirement and then a retrofit requirement on an aircraft no longer being manufactured. For aircraft no longer being manufactured, the OEM will have a solution for an FDR or CVR available, but it probably won't meet the specific requirements of every civil aviation authority in the world. The aircraft OEMs maintain data maps of their digital busses, describing exactly which parameters can be read from those busses. There are also several aircraft OEMs that interpret and validate the raw data extracted from the recorders onboard the aircraft that they manufacture.

What are the Canadian regulations for FDRs?
The Transport Canada (TCCA) regulations very closely mirror those of the United States. If you refer to the Canadian Aviation Regulations SOR/96-433, Part VI, Subpart 5, Division 2, 605.33, you will see the official regulations for Flight Data Recorder equipage for Canadian-registered aircraft.

What about other International requirements – EASA (Europe), ANAC (Brazil), DGCA (India)?
The Mexican regulations detailed earlier in this publication are based on the EASA regulation for FDR equipage. The main differences between the Mexican regulations and the EASA regulations are the type certification dates of the aircraft affected. The basic regulations are as follows:

- All turbine aircraft with 10 or more passenger seats weighing more than 5,700kg with a type certificate issued on or after April 1, 1998, must be equipped with an FDR capable of storing the last 25 hours of operation and record 17 specific parameters. Aircraft that weigh more than 27,000kg must be able to record 32 parameters. Aircraft that weigh less than 5,700kg must have an FDR capable of recording 17 parameters for the last 10 hours of operation. Aircraft type certificated before August 20, 2002, equipped with an EFIS (Electronic Flight Instrumentation System) must be able to record 42 parameters
- All turbine aircraft weighing more than 5,700kg with a type certificate issued on or after June 1, 1990, up to and including March 31, 1998, must be equipped with a digital FDR capable of storing the last 25 hours of operation and record 16 specific parameters. Those aircraft over 27,000kg must have the ability to record 32 parameters
- All turbine aircraft weighing more than 5,700kg with a type certificate issued before June 1, 1990, must be equipped with a digital FDR capable of storing the last 25 hours of operation and record 5 specific parameters. Those aircraft over 27,000kg that were type certificated after September 30, 1969, must have the ability to record 32 parameters

The ANAC (Brazil) and DGCA (India) regulations are very similar to the EASA rule.

KEY TERMS

AAM (Advanced Air Mobility)—Advanced air mobility, also called advanced aerial mobility, refers to the adoption of electric and hybrid aircraft to urban, suburban, and rural operations.

CVRS (Cockpit Digital Video Recording System)—A cockpit-mounted digital camera that records and stores voice and other sounds in the cockpit for a period of time.

CVR (Cockpit Voice Recorder)—A device that records the audio environment in the flight deck for accident and incident investigation purposes. The CVR records and stores the audio signals from the pilots' headsets and from an area microphone installed in the cockpit. The CVR will also record all datalink communications to and from an aircraft that is equipped with datalink.

FANS-1/A (Future Air Navigation Systems)—The communication formant for CPDLC (Controller Pilot Data Link Communications). ATN (Aeronautical Telecommunication Network) FANS 1 was developed by Boeing and later adopted by Airbus (FANS A). FANS 1/A consists of automatic position reports known as ADS-C, which require no pilot interaction, and CPDLC, the digital transmissions and responses sent back and forth between Air Traffic Control and the flight crew.

FDAU (Flight Data Acquisition Unit)—This unit receives discrete, analog, and digital parameters from sensors and avionics systems and routes them to an FDR. A DFDAU (Digital Flight Data Acquisition Unit) is a solid-state or digital version.

FDM (Flight Data Monitoring)—Flight data analysis is founded on OFDM (Operational Flight Data Monitoring), which is known as FOQA (Flight Operations Quality Assurance) in North America. The process routinely captures and analyzes recorder data in order to improve the safety of flight operations.

FDR (Flight Data Recorder)—The device used to record specific aircraft performance parameters, collecting and recording data from aircraft sensors in a format/unit designed to survive an accident. A DFDR (Digital Flight Data Recorder) is a solid-state or digital version of FDR. A CVFDR contains an FDR/CVR contained in the same unit.

ICAO (International Civil Aviation Organization)—An agency of the United Nations, directed by 193 countries, to standardize air transport policy and foster cooperation and diplomacy in air transport.

QAR (Quick-Access Recorder)—A QAR is an airborne FDR designed to provide quick and easy access to a subset of raw flight data.

SMS (Safety Management System)—A quality management system put in place at an organization that uses policies and processes designed to assess and mitigate risk. Incidents are reported and rectified continuously in order to constantly lower the level of risk. The goal is to prevent injuries and design and deliver products and services that are as safe as possible.

TSO (Technical Standard Order)—A TSO is a minimum performance standard for specified materials, parts, and appliances used on civil aircraft. When authorized to manufacture a material, part, or appliance to a TSO standard, this is referred to as TSO authorization. Receiving a TSO Authorization refers to both design and production approval. Receiving a TSO Authorization is not an approval to install and use the article in the aircraft. It means that the article meets the specific TSO, and the applicant is authorized to manufacture it.

ULB (Underwater Locator Beacon)—Also known as a ULD (Underwater Locating Device) or underwater acoustic beacon, this is fitted to flight recorders such as FDRs/CVRs. Activated by immersion in water, the ULB then emits an ultrasonic pulse at 37.5 kHz every second for at least 30 days. ULBs attached to the airframe transmit at 8.8kHz and are called low frequency ULBs.

BASIC 91-PARAMETER LIST BY FAA REGULATION

(1) Time;
(2) Pressure altitude;
(3) Indicated airspeed;
(4) Heading - primary flight crew reference (if selectable, record discrete, true or magnetic);
(5) Normal acceleration (Vertical);
(6) Pitch attitude;
(7) Roll attitude;
(8) Manual radio transmitter keying, or CVR/DFDR synchronization reference;
(9) Thrust/power of each engine - primary flight crew reference;
(10) Autopilot engagement status;
(11) Longitudinal acceleration;
(12) Pitch control input;
(13) Lateral control input;
(14) Rudder pedal input;
(15) Primary pitch control surface position;
(16) Primary lateral control surface position;
(17) Primary yaw control surface position;
(18) Lateral acceleration;

(19) Pitch trim surface position;
(20) Trailing edge flap or cockpit flap control selection;
(21) Leading edge flap or cockpit flap control selection;
(22) Each Thrust reverser position (or equivalent for propeller airplane);
(23) Ground spoiler position or speed brake selection;
(24) Outside or total air temperature;
(25) Automatic Flight Control System (AFCS) modes and engagement status, including autothrottle;
(26) Radio altitude;
(27) Localizer deviation, MLS Azimuth;
(28) Glideslope deviation, MLS Elevation;
(29) Marker beacon passage;
(30) Master warning;
(31) Air/ground sensor (primary airplane system reference nose or main gear);
(32) Angle of attack;
(33) Hydraulic pressure low (each system);
(34) Ground speed;
(35) Ground proximity warning system;
(36) Landing gear position or landing gear cockpit control selection;
(37) Drift angle;
(38) Wind speed and direction;
(39) Latitude and longitude;
(40) Stick shaker/pusher;
(41) Windshear;
(42) Throttle/power lever position;
(43) Additional engine parameters (as designated in appendix F of this part);
(44) Traffic alert and collision avoidance system;
(45) DME 1 and 2 distances;
(46) Nav 1 and 2 selected frequency;
(47) Selected barometric setting;
(48) Selected altitude;
(49) Selected speed;
(50) Selected mach;
(51) Selected vertical speed;
(52) Selected heading;
(53) Selected flight path;
(54) Selected decision height;
(55) EFIS display format;
(56) Multi-function/engine/alerts display format;
(57) Thrust command;

(58) Thrust target;
(59) Fuel quantity in CG trim tank;
(60) Primary Navigation System Reference;
(61) Icing;
(62) Engine warning each engine vibration;
(63) Engine warning each engine over temp;
(64) Engine warning each engine oil pressure low;
(65) Engine warning each engine over speed;
(66) Yaw trim surface position;
(67) Roll trim surface position;
(68) Brake pressure (selected system);
(69) Brake pedal application (left and right);
(70) Yaw or sideslip angle;
(71) Engine bleed valve position;
(72) De-icing or anti-icing system selection;
(73) Computed center of gravity;
(74) AC electrical bus status;
(75) DC electrical bus status;
(76) APU bleed valve position;
(77) Hydraulic pressure (each system);
(78) Loss of cabin pressure;
(79) Computer failure;
(80) Heads-up display;
(81) Para-visual display;
(82) Cockpit trim control input position - pitch;
(83) Cockpit trim control input position - roll;
(84) Cockpit trim control input position - yaw;
(85) Trailing edge flap and cockpit flap control position;
(86) Leading edge flap and cockpit flap control position;
(87) Ground spoiler position and speed brake selection;
(88) All cockpit flight control input forces (control wheel, control column, rudder pedal).
(89) Yaw damper status;
(90) Yaw damper command;
(91) Standby rudder valve status

SOURCES

AC 20-141b
AC 120-82
AC 20.186
14 CFR 135.152
14 CFR 91.609
ICAO Annex 6
EU-OPS 1
Official Mexican STANDARD NOM-022-SCT3-2011
Canadian Aviation Regulations SOR/96-433

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