Advisory Circular

U.S. Department
of Transportation

Federal Aviation
Administration

Subject: AIRWORTHINESS AND OPERATIONAL APPROVAL OF DIGITAL FLIGHT DATA RECORDER SYSTEMS

Date: 10/05/99 **AC No:** 20-141
Initiated by: AIR-130 **Change:**

1. PURPOSE. This advisory circular (AC) provides guidance on design, installation, and continued airworthiness of Digital Flight Data Recorder Systems (DFDRS). This AC is not mandatory and is not a regulation. It outlines one method of compliance with Title 14 of the Code of Federal Regulations. Instead of following this method, the applicant may elect to follow an alternate method, provided the alternate method is acceptable to the FAA Administrator for compliance with 14 CFR. Because the method of compliance presented in this AC is not mandatory, the term "must" used herein applies only to an applicant who chooses to follow this particular method without deviation.

2. RELATED SECTIONS OF 14 CFR. Sections of 14 CFR parts 23, 25, 27, 29, 91, 121, 125, 129, and 135 that prescribe design substantiation and operational approval requirements that are directly applicable to the DFDRS are listed here. See appendix 3 of this AC for typical additional design substantiation requirements of these parts.

a. Section 23.1459, Flight Recorders.

b. Section 25.1459, Flight Recorders.

c. Section 27.1459, Flight Recorders.

d. Section 29.1459, Flight Recorders.

e. Section 91.609, Flight Recorders and Cockpit Voice Recorders.

f. Section 121.343, Flight Recorders.

g. Section 121.344, Digital Flight Data Recorders for Transport Category Airplanes.

h. Section 121.344a, Digital Flight Data Recorders for 10-19 Seat Airplanes.

i. Section 125.225, Flight Recorders.

j. Section 125.226, Digital Flight Data Recorders.

k. Section 129.20, Digital Flight Data Recorders.

l. Section 135.152, Flight Recorders.

3. DEFINITIONS. The following definitions apply when these terms appear in the rule or this advisory circular:

a. Applicant. The applicant is an individual or organization that is seeking FAA approval for a digital flight data recorder (DFDR) installation. The approval may be a Type Certificate, (TC), Amended Type Certificate (ATC), or Supplemental Type Certificate (STC). The approval may apply to a single aircraft or to multiple aircraft of a single type design.

b. Correlation. A correlation describes the relationship between two variables. In this case the two variables are the raw data stored in the DFDR and the engineering units or discretes that this raw data represents. The applicant must establish the correlation between the raw data and the engineering units for all mandatory parameters. Reference Section 121.344 (j). The correlation required in the type certification regulations (Section 25.1459(c) for example) does not meet the requirement of Section 121.344(j). The applicant must use the correlation coefficient to describe this relationship. See appendix 1 for a method to determine the correlation coefficient.

c. Correlation Coefficient. The correlation coefficient is a number that describes the degree of relation between the raw data and the derived data. The correlation coefficient used here is the Pearson product-moment correlation coefficient. Its value may vary from minus one to plus one. A value of plus one indicates a perfect positive correlation. A value of zero indicates that there is no correlation or that any predictive capability between the derived data (using the equation) and the raw data is purely coincidental. A value of minus one indicates a perfect inverse relationship between the derived value and the raw data. The absolute value of the correlation coefficient must be equal to 0.9 or greater over the entire operating range of each mandatory parameter in order to accurately establish the conversion of recorded values to engineering units.

d. Date Manufactured. The date manufactured is the point in time at which the airplane inspection acceptance records reflect that the airplane is complete and meets the FAA-approved type design.

e. Digital Flight Data Acquisition Unit (DFDAU). A digital flight data acquisition unit (DFDAU) is an electronic device that collects, samples, conditions, and digitizes analog, discrete, and digital signals representing aircraft functions. It supplies a serial digital bit stream to the DFDR. A DFDAU differs from a Flight Data Acquisition Unit (FDAU) in that a DFDAU is capable of receiving both analog and digital data streams and converting them to the required DFDR digital data format. (See Aeronautical Radio Incorporated (ARINC) Characteristic 717.)

f. Digital Flight Data Recorder (DFDR). A digital flight data recorder (DFDR) is a recording device that utilizes a digital method to record and store data onto a storage medium and to retrieve that data from the medium. A DFDR may be the storage device in a recording system that includes a DFDAU or a FDAU. Or, it may be a stand-alone device using an internal data collection system to convert aircraft analog and discrete signals to digital form.

g. Digital Flight Data Recorder System (DFDRS). The digital flight data recorder system (DFDRS) is the equipment, sensors, wiring, equipment racks, and other items installed in the aircraft to record flight data. The DFDRS includes the following equipment items: DFDR, DFDAU or FDAU, and underwater locating device (ULD). The DFDRS also includes any sensors or transducers installed specifically to record flight data. For example, if it is necessary to install a horizontally mounted accelerometer to sense lateral acceleration, then this accelerometer is considered a part of the DFDRS. Conversely, the vertical accelerometer may exist on the aircraft for another reason (vertical flight control, for instance). If the DFDR takes vertical acceleration data from such an existing accelerometer, then the vertical accelerometer is not part of the DFDRS.

h. Flight Data Acquisition Unit (FDAU). A flight data acquisition unit (FDAU) is an electronic device that collects, samples, conditions, and digitizes analog signals representing aircraft functions. The FDAU does not normally have the capability to condition digital signals. It provides data to the DFDR in a digital bit stream. See the definition for DFDAU. (See ARINC Characteristic 573.)

i. Flight Data Recorder (FDR). A flight data recorder (FDR) is a recording device that directly receives analog signals representing various aircraft functions (e.g., vertical acceleration, heading, altitude, or airspeed) and records those signals in digital or analog format. Older FDR's recorded the signals by scratch with a stylus on a moving oscillographic medium that is typically a foil formed from steel or steel alloy. These older analog FDR installations typically conformed to ARINC Characteristic 542. The FAA now requires that DFDR’s be used in the U. S. commercial fleet.

j. Functional Check. A functional check is a quantitative check to determine if one or more functions of an item perform within specified limits. When applied to a DFDR parameter, the functional check determines that the recorded parameter is within the limits (range, accuracy, sampling rate, and resolution) specified in the operating rule. The applicant must accomplish a functional check for all mandatory parameters for the “first of type” installation testing. The applicant must perform the “first of type” installation testing for an FAA approval (TC, ATC, or STC). During the "first of type" functional check, it may not be feasible to stimulate some sensors to their specified limits. In such instances it is acceptable to simulate the sensor output using suitable test equipment. The operator must include a different functional check in the maintenance program. This maintenance functional check applies to those parameters that can neither be read out during the flight data download, nor functionally checked as part of other aircraft systems. The maintenance functional check may simulate sensor or transducer outputs to check the range, accuracy, resolution, and sampling rate of the recorded data. However, the instructions for continued airworthness and the operator's maintenance program must prescribe a periodic functional check of each of these transducers or sensors for accuracy and range.

k. Installed and Connected to the Recording System. The term installed and connected to the recording system refers to the requirement to record additional parameters in addition to those specifically identified in the regulation (22, 34, 57, or 88 parameters depending upon the date the aircraft was manufactured). The DFDRS must record the parameters that were recorded by the airplane's existing DFDRS on July 16, 1996 if sufficient capacity is available in the upgraded DFDR. However, an operator is not required to upgrade the capacity of an installed recording system beyond that needed to record the mandated parameters. In other words, an operator may not discontinue recording parameters it was recording as of July 16, 1996, if they can be easily accommodated. Thus, if a retrofitted DFDRS can accommodate additional parameters, the operator must continue to record any parameters that were not specifically mandated, but that may be accommodated by the upgraded DFDRS. The FAA considers a parameter to be easily accommodated if it is provided by an installed system and it is already connected to the databus. (See sufficient capacity.)

l. Operational Check. An operational check is a task to determine that an item is fulfilling its intended purpose. An operational check is a failure-finding task and does not determine if the item is performing within specified limits. When applied to a DFDR, the operational check determines that the DFDR is active and recording each parameter value within the normal operating range of the sensor. The operational check must also verify each electrical interface to the DFDRS. A check to determine the reasonableness and quality of the data being recorded is considered an operational check.

m. Single Source. The term single source applies to certain split flight control parameters. It means that if it is necessary to conserve capacity in order to record the required parameters, the DFDR must record the position of only one of the two flight control positions. For example, the DFDR may record the position of the aileron bellcrank instead of each aileron surface position. However, any recording from a single source must be made so that the position of the flight control can be differentiated from the position of the flight control surface. In the example given, the installation instructions must instruct the installer to place the aileron surface position sensor on one or the other bellcrank lobes to which one of the aileron surface actuator arms is attached -- not the lobe to which the control yoke is attached.

n. Split Flight Control Parameter. The term split flight control parameters applies to flight control and flight control surface parameters when the flight control system design allows the flight-crew to disconnect the pilot's controls from the copilot's controls. This flight control system design is also known as breakaway capability. The DFDRS must record multiple flight control positions, as well as multiple flight control surface positions. For example, an aircraft flight control system design may allow the flightcrew to disconnect the pilot lateral (aileron) control from the copilot lateral (aileron) control. The disconnect would leave the left aileron connected to the pilot lateral (aileron) control and the right aileron connected to the copilot lateral (aileron) control. This would leave the pilot capable of operating the left aileron only, and the copilot capable of operating the right only. Thus, the pilot and copilot control inputs (parameter 13) would be a split parameter necessitating that each pilot's lateral control position be recorded. The DFDRS must record both the left and the right lateral control surface (aileron) position (parameter 16) as well.

o. Sufficient Capacity. The term sufficient capacity addresses the existing capacity of the installed DFDRS (either before retrofit or in new production) with regard to the addition of available parameters to be connected to the recording system. These parameters are in addition to the 22, 34, 57, or 88 parameter requirements, depending upon the airplane date of manufacture. Adding these parameters should not force the installation of a higher capacity acquisition unit (FDAU or DFDAU) or DFDR to accommodate these parameters. For example: If the existing DFDRS functions at a 64 word-per-second rate, the rule does not require the applicant to upgrade the system to function at a 128 word-per-second rate to accommodate these parameters, even if it means disconnecting previously recorded parameters that are not required to be recorded. (See the definition for installed and connected to the recording system.)

p. When an Information Source is Installed. When the term when an information source is installed appears in the parameter listing 1-88 of the appropriate 14 CFR section or appendix, the parameter is mandatory only if the airplane is fitted with a system that provides that capability. For example, it is not necessary to install an ice detection system to comply with parameter 61; but, if an ice detection system is already installed on the aircraft, the DFDRS must record its operation.

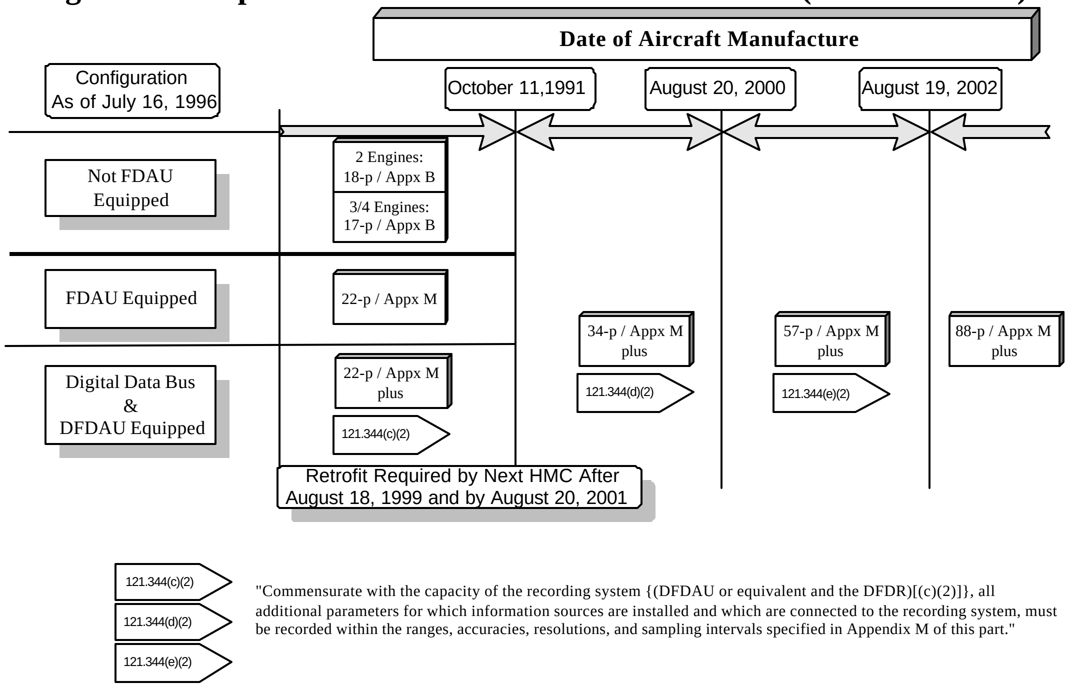
4. SCOPE. This advisory circular provides policy for type certification of a digital flight data recorder system installation. It applies to installations that are intended to comply with the requirements of the revisions to digital flight data recorder operating rules that became effective August 18, 1997. The revised operating rules are Sections 121.344, 121.344a, 125.226, 129.20, and 135.152. This AC also provides guidance to the aircraft operator for compliance with the operating rules after DFDRS installation.

5. BACKGROUND. On July 17, 1997, the Federal Aviation Administration (FAA) revised certain sections of 14 CFR to require that certain aircraft be equipped to accommodate additional digital flight data recorder parameters. The purpose of the revision was to provide additional information to enable the investigative authority -- the National Transportation Safety Board (NTSB) in the U. S. -- to conduct more thorough investigations of accidents and incidents. The data recorded would also be available to industry to enable the prediction of trends that may be useful in determining modifications needed to avoid accidents and incidents. The revised rules require that certain turbine-engine-powered airplanes and rotorcraft having 10 or more passenger seats be equipped to record specified parameters. Many currently operating

aircraft have low capacity Flight Data Recorder Systems installed. A rule requiring immediate retrofits would have significantly impacted the air transportation industry economically both in scheduling and equipment installation costs. In some cases the equipment had not yet been developed. Accordingly, the FAA provided an extended schedule for retrofit of in-service aircraft. This AC provides guidance to applicants for a Supplemental Type Certificate (STC), and to individuals who are responsible for obtaining operating approval for these DFDR's. Aircraft manufacturers who intend to install DFDR's in newly-manufactured aircraft may also use this guidance.

6. COMPLIANCE SCHEDULE, OPERATING CERTIFICATE HOLDERS. A holder of an air operating certificate may not operate an aircraft on its operations specification in air transportation unless that airplane complies with the flight data recorder requirements of the appropriate 14 CFR part (121,125, 129, or 135). Those conducting other operations of multiengine, turbine-engine-powered airplanes or rotorcraft having 10 or more passenger seats must comply with the flight data recorder requirements of section 91.609(c). All multiengine, turbine-engine-powered multiengine airplanes having 10 or more passenger seats that are operating in air transportation under parts 121, 125, 129, or 135 and were manufactured after August 19, 2002, must be equipped with a DFDRS that records 88 parameters as listed in the appropriate CFR appendix. The term "having 10 or more passenger seats" refers to the actual number of seat provisions available for use (seat rail attach positions) in the aircraft as it is configured for operation, not the approved seating capacity entered on the Type Certificate Data Sheet (TCDS). The rule change increased to 25 hours the DFDR recording capability requirement for helicopters operating under part 135 authority but did not affect other helicopter requirements. Except for certain excluded aircraft, the rules provide a retrofit schedule for existing and in-production aircraft. Figure 1 summarizes the schedule of part 121 DFDRS requirements. For a more detailed description of the requirements and retrofit schedule for these and other aircraft refer to the applicable rule or to appendix 2 of this AC.

Figure 1. Compliance Schedule for DFDRS Installations (Section 121.344)



7. <u>TYPE CERTIFICATION</u>. The applicant must obtain FAA approval to install or to retrofit a DFDR and components. The applicant may apply for a TC, an ATC, or an STC. The FAA will not make field approvals. The applicant must demonstrate compliance with the applicable regulations included in the type certification basis for the aircraft. Appendix 3 lists typical certification requirements that are applicable depending upon the certification basis of the aircraft. The type certificate data sheet (TCDS) referenced in the type certificate normally identifies the applicable regulations. An applicant must demonstrate compliance with the appropriate certification requirements as instructed by the approving Aircraft Certification Office (ACO). (See appendix 3.)

a. <u>DFDRS Descriptive Data</u>. The applicant must include in the system description the make and the model or part number of the DFDR, FDAU, or DFDAU (or equivalent). Include a listing of each parameter recorded and identify any transducers or sensors installed specifically for the purpose of sensing required data. Such identification must include the manufacturer and part number of the sensor. For those sensors not dedicated exclusively to the DFDRS, identify and include in the system description the sensor source and the associated digital data bus source. The description must identify any reliance upon pneumatic inputs directly to the DFDRS for pitot-static information. Identify those components of the DFDRS that meet TSO standards including the TSO number and any authorized deviations from the TSO requirements. Describe any necessary structural alterations associated with the installation. The description must include a wiring diagram and schematic and must describe all dedicated wires. Identify all interfaces to other installed equipment and systems.

b. <u>Intended Function</u>. The applicant must provide a list of all parameters that the DFDR will record and their specifications (range, accuracy, sampling rate, sampling interval, and resolution). The applicant must demonstrate, by tests, that the DFDRS meets these specifications. These tests are normally performed using simulated inputs to the DFDRS and by activating transducers and sensors installed as part of the DFDRS. Where the aircraft sensor is a synchro, and the installation design allows switching of the sensor or the digital bus during flight, the applicant must demonstrate performance in all switched positions. As part of this test, the applicant must provide a correlation document (data stream format and correlation document as described in appendix 1).

NOTE: Before performing ground or flight tests on the DFDRS installation, the applicant must perform a conformity check. This check must demonstrate that the DFDRS installation conforms to the design data that will be cited on the type certificate, amended type certificate, or supplemental type certificate.

(1) The applicant must identify any parameters that are filtered before they are recorded. For these parameters, the applicant must show, by test, that there is no significant difference between the recorded parameter data under both static and dynamic (parameter undergoing change at the maximum rate expected when operating the aircraft in accordance with the flight manual) conditions. For purposes of this test, the term "no significant difference" means that any differences between the data recorded under static conditions and the data recorded under dynamic conditions should be less than the correlation coefficient derived using static parameter values.

(2) The applicant must also perform a ground cockpit compatibility check to demonstrate performance of the DFDRS installation. This compatibility demonstration must include:

(a) A demonstration that the circuit breaker can be identified and reset from a flightcrew position (if a circuit breaker is provided for crew reset);

(b) A check that the DFDR "preflight check" indicator or display is visible (or aural tone is audible) to the flightcrew; and

(c) A demonstration of any DFDR-related items in the airplane flight manual (supplement) to verify that aircraft flight manual (AFM) procedures have not been invalidated by the installation..

(3) The applicant must perform a test to demonstrate that the DFDRS is not susceptible to electromagnetic or radio frequency interference (EMI/RFI) and that it does not generate such interference in essential and flight-critical systems. The applicant must demonstrate EMI/RFI compatibility with engines and all essential systems operating for a new DFDRS installation.

NOTE: The STC process does not provide for findings of compliance with operating rules such as section 121.344. An FAA Flight Standards inspector must make such findings of compliance for individual aircraft upon completion of the aircraft installation. However, an applicant for type certificate approval (TC, ATC, or STC) may facilitate the operator's later demonstration of compliance to the operating rule by referencing the appropriate appendix and parameter numbers of parts 121, 125, or 135 for the specifications met when demonstrating that the DFDRS performs its intended function. The FAA inspector may use the test report to support a finding of compliance with the operating rule. The applicant should substantiate any discrepancies between the parameter specifications in the appropriate appendix of the operating rule and those demonstrated by test. Such substantiation is needed for the ACO to find "novel, unique design, or operational characteristic."(See Section 25.1459(e) or equivalent.) The operator may later use this substantiation to support a petition for exemption from the operating rule. For example, the applicant may need to substantiate a unique design characteristic to change the way the DFDR records a required parameter if such recording would compromise a critical function of the aircraft. In this case, the operator that installs the FAA-approved system must then request an exemption from the parameter-recording requirement. (See 14 CFR section 11.25 for procedures to petition for an exemption.)

(4) The applicant must demonstrate that the DFDRS performs as intended, that it does not cause electromagnetic interference (EMI) in essential or flight critical systems, and that electromagnetic fields from other operating electrical and electronic systems and components do not cause noise or data dropouts in the DFDR recorded data. If the applicant cannot demonstrate these capabilities using ground tests, a flight test must be performed. After the flight test, the applicant must conduct a reasonableness and quality check of the DFDR data from the flight test. The purpose of this check is to demonstrate that each parameter is being recorded properly and that any data dropouts or noise do not interfere with the ability to interpret the data. Appendix 4 presents a typical flight test sequence and the manually recorded data needed to conduct the reasonableness and quality check. During the flight test, the applicant must demonstrate that the DFDRS is not susceptible to electromagnetic or radio frequency interference (EMI/RFI) and that the DFDRS does not generate such interference in essential or flight-critical systems.

NOTE: Using the flight test data, the applicant must confirm that the DFDR begins to operate no later than the time that the aircraft begins its takeoff roll and continues to operate until after the aircraft has completed its landing roll. For rotorcraft, the DFDR must operate from the instant the rotorcraft begins its liftoff until it has landed.

c. Equipment and Sensors. The applicant must present evidence that the equipment and sensors that are to be installed as part of the retrofit are FAA approved or obtain FAA approval for them. A DFDR or DFDAU that has been manufactured under TSO C-124 or C-124a authorization is FAA approved. Likewise, a ULD that has been manufactured under TSO C-121 authorization is FAA approved. DFDRS equipment installed in turbine-engine-powered airplanes having 10 or more passenger seats and manufactured after August 18, 2000, must conform to TSO C124 or TSO C124a. Acceptable guidelines for documentation of DFDR data content and format are also available in the Flight Recorder Configuration Standard (FRCS), Document TP13140E. The FRCS is available from Transport Canada Safety and Security at:

Transportation Development Centre
800 Rene Levesque Blvd. West, Suite 800
Montreal, Quebec, Canada H3B 1X9
Telephone, (514) 283-0000, FAX (514) 283-7158
e-mail: tdccdt@tc.gc.ca

NOTE: The DFDR installed in aircraft operated under 14 CFR parts 121, 125, 129, and 135 must be capable of recording flight data for 24 hours or more. Therefore, in order to avoid installation of an 8-hour recorder in these aircraft, any DFDR that is capable of retaining no more than 8 hours of data must bear a placard stating: "Approved for use in aircraft operating under 14 CFR part 91 only." The placard must be printed in 5/16 inch bold block letters. The placard must be affixed to a surface of the DFDR so that it is easily visible when the DFDR is installed.

(1) Altitude and Airspeed Sensors. When an air data computer is installed, the pressure altitude and indicated or calibrated airspeed must be recorded from the air data computer. When two air data computers are installed, one supplying the pilot instruments and the other supplying the co-pilot instruments, the pressure altitude and indicted or calibrated airspeed must be recorded from both air data computers. However, the air data computer outputs may be sampled alternately once every 2 seconds to produce the sampling interval of 1 second. When there is no air data computer, the pressure altitude and indicated or calibrated airspeed may be derived from either of the pilot's instrument systems or it may be derived from a separate pitot-static system. Where the data is derived from the pilots' instruments, the pilots' instruments must not be impaired. Where the data is derived from a separate pitot-static system, the accuracy of the data must be equal to that of the pilots' instruments over the full flight envelope of the aircraft.

(2) Control Position and Forces (non-fly-by wire). Control positions and control forces must be measured at the control columns, control wheels, and rudder pedals, if practical. Where the applicant shows that this is impractical, the positions and forces may be measured on the first lever arm or on the first bell crank in the control linkage from the control. Should the applicant determine that installation of the sensor on this first control arm or bell crank is

impractical, the applicant should conduct an analysis to show that the likelihood of mechanical interference that could invalidate the recorded position and force values is improbable ($1x10^{-6}$).

(3) Thrust Command and Thrust Target. Thrust command and thrust target are typically available on airplanes equipped with a Full Authority Digital Electronic Control (FADEC). Thrust command is the thrust required by the FADEC for some predefined schedule. Thrust target is the thrust to be achieved at the end of the thrust command schedule. Once the thrust target is achieved, the thrust command and the thrust target will be the same.

(4) Computer Failure Discrete. This parameter is a discrete and should be activated upon failure of any computer that could directly affect the primary and secondary flight controls or the engine controls (primarily the throttles). Some examples of computers that should be monitored for failure are those that are a part of the Flight Management System, the auto-throttle system, and the autopilot. Furthermore, if a computer drives any of the above computers, and there is no discrete transmitted to that computer from the device, that device's computer should also be monitored.

(5) Multiple Control Surfaces (flap sections, aileron/spoiler speed brake panels) and Combinations for Lateral Control. Ailerons on each wing must be monitored separately. Multiple aileron surfaces that are mounted on the same wing must be monitored separately unless the designer shows that it is improbable that all surfaces would not deploy as intended. All secondary control surfaces (e.g., flaps, speed brakes, and spoilers) that normally activate together but can activate independently of each other should also be monitored separately unless the designer shows that it is improbable that a surface would not deploy as intended.

(6) Multiple Thrust Reverser Buckets. Each individual thrust reverser bucket must be monitored unless the designer shows that it is improbable that an individual bucket would deploy without intentional deployment of all buckets at once.

(7) Hydraulic Pressure. Hydraulic pressure low, each system (parameter 33) and hydraulic pressure each system (parameter 77) are both required parameters. Although hydraulic pressure low is defined as a discrete the comment in the range column of appendix M indicates that it may also be recorded as an analog signal representing the actual value of the hydraulic pressure. Thus, either the hydraulic pressure LO discrete or the actual analog hydraulic pressure may be recorded for all DFDRS installations except those on airplanes manufactured after August 19, 2002. For airplanes manufactured after August 19, 2002, both parameter 33 and parameter 77 are required. Thus, both the hydraulic pressure low discrete (parameter 33) and hydraulic pressure (parameter 77) must be recorded for these airplanes.

(8) Safety Evaluation of Sensors Installed in Flight Control Systems. Some flight control surface and flight control input sensors consist of rotary synchros that are tied into the flight control system using mechanical arms and links. The ends of the links (rod ends) and the synchros have bearings that may be subject to seizure due to loss of lubrication. Such seizures may jam flight controls resulting in a catastrophic failure condition. The applicant must conduct

a safety analysis to evaluate the reliability and fail-safe aspects of sensor hardware installed in flight control paths. The analysis should demonstrate that no catastrophic failure would occur during the life of the aircraft. As a result of this study, the applicant may find it necessary to prescribe periodic inspection or replacement of the sensor(s) in the instructions for continued airworthiness.

d. Combination CVR/DFDR Units. Under longstanding FAA policy an applicant may install a combination cockpit voice recorder (CVR) and DFDR unit instead of the DFDR. However, the combination CVR/DFDR may not serve as both the required DFDR and the required CVR. That is, the applicant may use a combination CVR/DFDR for either the required DFDR or CVR, or the applicant may install two combination CVR/DFDR units in the aircraft, one for each required system.

e. Software. For those DFDR's having DO-178B Level E or DO-178A Level 3 software installed, and those DFDR's for which no software approval exists, the applicant must:

(1) Obtain certification from the equipment manufacturer that the source code has been archived.

(2) Obtain certification from the equipment manufacturer that the executable object code can be regenerated from the archived source code.

(3) Demonstrate that the software to be loaded during DFDRS installation or during DFDRS maintenance can be successfully loaded through the use of released procedures. These procedures should be included as part of the installation instructions or the instructions for continued airworthiness, as appropriate.

f. Weight and Balance. The applicant must determine the effect of each item of equipment that has been removed or installed on the aircraft weight and balance. The applicant must present a report showing the net change in weight and moment (or moment arm). The report must show how the applicant determined this net change. The applicant must also submit a flight manual supplement to the ACO for approval, if the installation results in changes to the weight and balance procedures in the airplane flight manual.

g. Electrical Loads Analysis. The applicant must determine the effects of each installed and removed item of electrical equipment on the electrical load to the aircraft power distribution system. The applicant must present a report showing the net change in the electrical load on each affected bus and how the applicant computed this net change. The applicant must also identify any necessary changes in circuit protective devices. The net change to the load carrying capability of the essential bus must not result in interruption or otherwise adversely affect power supplied to items on that bus.

h. Electrical Power Source. The DFDR must receive its operating electrical power from the bus that allows maximum reliability for the DFDRS. The applicant may not add the DFDR to any bus if the addition would jeopardize essential or emergency loads. The applicant must connect the DFDRS and the cockpit voice recorder (CVR) to power busses that are separate and supplied by independent power sources. If the DFDRS cannot be added to the emergency or essential bus, the applicant should consider providing two separate and independent sources of electrical power for each DFDR and its associated FDAU or DFDAU. In addition, the applicant should consider providing that each DFDR and its associated FDAU or DFDAU automatically switch between the two power sources to maintain flight data recording in the event of a bus failure. Such provision of two separate and independent power sources would ensure that available data essential to accident investigation is recorded throughout the entire accident sequence.

> *NOTE: If the applicant is upgrading an existing approved DFDRS installation in order to comply with the new operating requirements of Amendment 121-266,*
> *125-30, or 135-69, and the upgrade would not otherwise require revised power circuitry, the applicant need not revise existing power circuitry to provide automatic switching capability.*

i. Circuit Protective Devices. If a circuit protective device for the DFDR is provided in the cockpit, it must be resettable and located so that it can be readily reset in flight. Advisory Circular 25.1357-1 describes an acceptable means of making circuit protective devices accessible so that they can be reset in flight.

j. Preflight Monitoring Means. The preflight monitoring means is an aural or visual indicator in the cockpit that is activated when any one of a combination of system status monitors and built-in test capabilities fail. For example, an indicator light may monitor the following functions, depending upon availability of built-in test capability:

(1) Loss of system electrical power;

(2) Failure of the data acquisition and processing equipment; and

(3) Failure of the recording medium and/or drive mechanism.

k. Aircraft Flight Manual Review. The applicant must review the aircraft flight manual (AFM) and supplements to determine that they are compatible with the DFDRS installation. The applicant must provide an approved AFM supplement to eliminate any incompatibilities.

l. Instructions for Continued Airworthiness. The applicant must provide instructions for continued airworthiness as part of the substantiating data. These instructions must include as a minimum:

(1) A document containing the data stream format and correlation data outlined in appendix 1.

(2) An identification of the transducers installed exclusively for the DFDRS (that is, those that supply signals only to the DFDRS and not to other aircraft systems). The signals from these transducers cannot be verified during checks of other aircraft systems and equipment; therefore, they must be checked using specifically-devised procedures. For example: vertical, longitudinal, and if applicable, lateral acceleration.

(3) A document providing procedures for a ground check. The ground check must confirm the recorded value of each parameter that is generated by a transducer or other signal source exclusive to the DFDRS. The document must provide sufficient information to verify the accuracy of the recorded data (as required by part 121, appendix B or M; part 125, appendix E; or part 135, appendix B, C, or F).

(4) A document providing procedures for performing an operational and functional ground check. The document must provide sufficient information such that a technician can assess the reasonableness of the recorded values for each mandatory parameter and the quality of the recording. The document must enable the technician to conduct an operational (reasonableness and quality) check by periodic readout of the recorded parameters from any flight. The readout must be in engineering units and discrete states. It must also provide procedures (and recommended check intervals) to functionally check parameters, such as warning discretes, that are not typically activated and recorded during the aircraft operation segments being used for the operational check. The document may reference procedures for such checks furnished in the aircraft manufacturer's instructions for continued airworthiness. See appendix 5 for typical reasonableness and quality check instructions.

NOTE: The term reasonableness refers to the read-out of recorded parameter values. The procedures determine reasonableness of parameters in a typical segment of flight by comparing these readouts to expected values, directions of change, and rates of change. The flight segments are: takeoff roll, takeoff, climb, cruise, approach, landing, and landing roll-out. . The reasonableness check should be accomplished in those segments that exercise the majority of the parameters. These segments are takeoff, climb, approach, and landing. If parameters are recorded during taxi, they should be used as well. An example reasonableness check might be to examine the altitude value during taxi. An altitude reading during taxi or takeoff roll, that deviates significantly from field elevation should signal the analyst to check the altimeter setting to determine if it was correct or to check the static system and altimeter. An example of poor data quality is 15 data "drop-outs" in a 45-second period of flight for parameter (13) pitch control. This indicates poor data quality since the analyst would find it difficult to correlate pilot control inputs to aircraft attitude and position. The quality assessment must determine that there are no instances of noise or data dropouts that interfere with the analysts' ability to correlate interdependent parameters.

(5) A document providing repair and replacement instructions for DFDRS equipment and sensors. This document must include instructions for conducting a functional check of the affected parameter(s). The functional check must include instructions for verifying that the data stream format and correlation documentation is correct.

(6) If the retrofit includes a change to the underwater locating device (ULD), the applicant must provide instructions for periodically replacing the ULD battery and conducting an operational check of the ULD. The replacement period must be consistent with the battery manufacturer's life limit. The applicant must include instructions for how to access the ULD. Advisory Circular 21-10A, Flight Recorder and Cockpit Voice Recorder Underwater Locating Devices, provides guidance for ULD installations.

NOTE: If the ULD battery is not accessible, the instructions must be for replacement of the ULD itself.

(7) The applicant may design the installation to accommodate DFDRS equipment of different part numbers or of different models and part numbers. For example, the DFDRS equipment manufacturer may assign one part number to equipment that meets the requirements of TSO C124 and another part number to equipment that meets TSO C124a. The two different part-numbered DFDR's are identical except that the latter has been shown to withstand the more severe fire resistance test requirements of TSO C124a. Since the FAA accepts both DFDR's, the applicant may wish to allow installers to select either DFDR for installation. In this case, the applicant must provide a list identifying the interchangeable items of equipment by make, model, and part number.

8. AFTER INSTALLATION. Before a newly manufactured aircraft is put into service or a retrofitted aircraft is returned to service, the operator must demonstrate conformity to the type design or supplemental type design data. The operator must demonstrate this conformity to an FAA airworthiness inspector. The inspector must determine that the operator has demonstrated the following functions, or that the FAA has exempted the operator from the operational requirement:

a. Parameter Operational Check. The operator must perform an operational and functional check to determine that each required parameter is being recorded, that the recorded value is reasonable, and that data quality is sufficient to interpret the data. This operational and functional check is also referred to as a reasonableness and quality check. Any parameter that is generated by a sensor or transducer installed as part of the DFDRS or exclusively used by the DFDRS must be functionally checked at the time that the operational check is accomplished. See paragraph 7.l.(3). The operator must retain the downloaded data (raw data in electronic format that can be deciphered using the Data Stream Format contained in the correlation document is acceptable) used in this check as a permanent part of the aircraft records. The operator must note in its maintenance program how to access the downloaded data used in this check. See paragraph 7.l. (4) for a description of the operational and functional check.

b. Correlation Document (Data Stream Format and Correlation Document). The operator may use an approved correlation document supplied by the FAA approval holder or develop a separate correlation document. The document describes the data stream format and includes correlation data for each mandatory parameter. Where the operator has obtained approval to deviate from the approved installation data, the operator must verify that the approval holder-supplied correlation data remains valid for those mandatory parameters affected by the deviation. The operator must generate and maintain individual aircraft correlation data where significant deviations from the FAA-approved correlation data exist. The deviation is significant if the applicant cannot demonstrate that the difference between the derived data for the "as installed DFDRS" and the derived data for the "FAA approved DFDRS" is within the accuracy specification of the appropriate appendix. (See appendix 1.)

c. Parameter Specification Demonstration. The operator must verify that all parameters required by the operating rule are being recorded to the specifications (time correlation, range, resolution, accuracy, and sampling rate) provided in the appropriate appendix. For multiple DFDRS installations, as described in section 121.344(j), the operator may demonstrate compliance by comparing the FAA approval holder's approved parameter list and correlation document (data stream format and correlation document as described in appendix 1) to the appropriate appendix of the operating rule.

d. Data Retention Provisions. The operator must demonstrate that when removing a DFDR from an aircraft, all recorded flight data is retained until the operator has operated the aircraft for an additional 25 hours or more. The term "operate the aircraft for an additional 25 hours or more" refers to the total time of all flight since the DFDR was removed, including the time from start of the use of the checklist (before starting engines for the purpose of flight), to completion of the final checklist at the termination of flight.

9. MAINTENANCE PROGRAM. Each operator must change its maintenance program, as necessary, to include administrative procedures for scheduling, accomplishing, and recording maintenance and inspection actions to accommodate the required changes to the DFDR system. The maintenance program must identify inspection items, establish time-in-service intervals for maintenance and inspections, and provide the details of the proposed methods and procedures. An operator may include the maintenance and inspection program for the underwater locator device (ULD) in the DFDR system program or develop it separately. The maintenance program must include the following items:

a. Describe the DFDRS. The system description must include the make and model, or part number of the DFDR and each DFDAU or FDAU. It must include a listing of each parameter recorded, and must identify any transducers installed specifically for the purpose of sensing DFDR required data. Such identification must include the manufacturer and part number of each sensor. The description must include a wiring diagram and schematic, and describe all dedicated wires and digital data busses. The system description must identify all interfaces to other installed equipment and systems.

b. Describe the scheduled maintenance tasks for each component of the DFDRS. This description must include an operational and functional ground check of all mandatory parameters recorded by the DFDR. The operational check procedure must determine the reasonableness of mandatory parameters recorded by the DFDR. It must also determine that the data quality pertaining to noise and data dropouts allows one to correlate related parameters. The operational check must be accompanied by a functional check to verify the performance of any mandatory parameters not verified from the flight data used during operational check or by functional tests of other aircraft systems. The operational check description must provide sufficient information to assess the reasonableness and quality of the recorded values. The operator must use a periodic readout or electronic data extraction of the flight recorder to accomplish this requirement. The operator must include a separate operational check for mandatory parameters, such as warning discretes, (If the DFDAU posts in the recorded data that the bus is operational, an existing operational test that shows that the DFDAU is receiving data is adequate for this purpose) not typically activated and recorded during the aircraft operation segments being used for the operational check. The ground operational check must also include procedures to determine the reasonableness of any recorded non-mandatory parameters. Appendix 5 describes typical reasonableness and quality check requirements for a 34-parameter installation.

> *NOTE: Some test units are available that record or display the data going into the DFDR rather than downloading the data actually stored in the DFDR. Such units are not acceptable for use in conducting the reasonableness and quality check as it does not allow one to assess the quality of recorded data.*

c. Provide for the retention of DFDR correlation document data stream format and correlation document as described in appendix 1 applicable to each individual aircraft. Provide for retention of additional documents needed to enable accurate conversion of recorded digital values to their corresponding engineering units or discrete states. These documents must also be readily available so that they can be delivered to the FAA or the National Transportation Safety Board (NTSB) after an accident or a reportable occurrence. The data stream format and correlation document must provide the information described in appendix 1 of this AC.

d. Provide for updating the correlation and data conversion documentation for each DFDRS installation. These procedures must also provide for an update, upon modification of a system that provides parameter input to the DFDR system.

e. Establish a schedule for accomplishing an operational and functional ground check at intervals not to exceed 12 calendar months. An operator may adjust this 12-month interval based upon findings made under the "performance analysis function" of its continuing analysis and surveillance program. The operator must demonstrate to the FAA that these findings are satisfactory prior to adjusting the repeat interval.

f. Establish a schedule for ULD functional check and battery or ULD replacement.

g. Provide for the retention of the DFDR readouts (Operators may retain the actual DFDR data used for the operational check instead of the data readout or printout. However, the operator must be able to print out the data or otherwise provide it in a readable format at the request of the FAA or the NTSB) and the maintenance job card or instructions from the most recent DFDRS ground operational and functional check. The DFDR data should be retained in electronic format. However, if the operator does not have the capability to download or retain the data in electronic format, a computer printout(s) or an oscillograph trace is acceptable. Provide for retention of these records until they are replaced by records from a subsequent operational check. The operator must provide for retention of the last operational and functional check record for at least 6 months after the operator has sold or otherwise permanently removed the aircraft from its operating certificate.

10. POLICY FOR PART 135 AIRCRAFT. Section 135.152, Flight Recorders, states that aircraft brought onto the U.S. register after October 11, 1991, are required to meet the recorder requirements of that section. Several years ago, the Flight Standards Service policy was that airplanes that were on the U.S. register before October 11, 1991, were taken off, and were added to the register again after October 11, 1991, did not have to meet the flight recorder requirements because of the previous registration. As noted in the preamble to the final rule adopting the 1997 flight recorder requirements, this policy is inconsistent with the clear language of the rule and with the rules making scheduled commuter airplanes subject to part 121 requirements. The FAA officially changed this policy effective August 1997 (62 FR 38374, July 17, 1997). Operators of airplanes or rotorcraft that were operating without flight recorders pursuant to the old policy have until August 18, 2001, to comply with § 135.152. This compliance time does not appear in the regulation itself to prevent confusion with those aircraft that are required to comply at the time they are placed on the U.S. register.

James C. Jones
Manager, Aircraft Engineering Division

APPENDIX 1. STANDARD DATA FORMAT FOR DIGITAL FLIGHT DATA RECORDERS DATA STREAM FORMAT AND CORRELATION DOCUMENTATION

The Digital Flight Data Recorder System (DFDRS) records flight data in a digital format. Data is normally grouped into words that are synchronized in a data stream. The data stream must be correlated to engineering units or to discrete states in order for an accident investigator to use the data. This appendix provides a standard for the data stream format and correlation documentation that operators must maintain to aid accident investigators in interpreting recorded flight data. Acceptable guidelines for documentation of DFDR data content and format are also available in the Flight Recorder Configuration Standard (FRCS), Document TP13140E. The FRCS is available from Transport Canada Safety and Security at:

Transportation Development Centre
800 Rene Levesque Blvd. West, Suite 800
Montreal, Quebec, Canada H3B 1X9
Telephone, (514) 283-0000, FAX (514) 283-7158
e-mail: tdccdt@tc.gc.ca

1. Definitions. The following definitions apply to terminology often used in the DFDR correlation documentation. These definitions are derived from ARINC Characteristic 717-9, Flight Data Acquisition and Recording System, dated December 3, 1993. An operator using another data stream format must provide definitions unique to its format in the correlation documentation.

a. DFDR Bit Number. The DFDR bit number defines a specific bit location within a DFDR system word on the output from the DFDR. The DFDR bit number is used to locate the bits that are dedicated to a given parameter within the word. For example DFDR bit numbers 3-12 indicate bit 3 through bit 12. The lowest bit number is normally the least significant bit.

b. Lexicon. A dictionary of all Mnemonic Codes and the associated parameters each represents.

c. Mnemonic Code. Mnemonic code is an abbreviation of the parameter name. It is intended to be used in formats where the parameter name is too large. The first eight characters of the mnemonic code must be used to identify the parameter as described in the applicable appendix (14 CFR part 121, appendix B or M; 14 CFR part 125 appendix E; or 14 CFR part 135, appendix F). The aircraft manufacturer normally assigns a mnemonic code to each parameter. This code is normally correlated to the parameter name in the aircraft manufacturer's interface control document. However, a modifier or an operator may assign a mnemonic code to an

APPENDIX 1. STANDARD DATA FORMAT FOR DIGITAL FLIGHT DATA RECORDERS DATA STREAM FORMAT AND CORRELATION DOCUMENTATION (CONTINUED)

added parameter. The mnemonic code must uniquely identify the parameter relative to all other parameters being recorded by the DFDR. Additional characters may be necessary to uniquely identify the parameter as installed on the aircraft. Table 1-5 contains a lexicon of some typical mnemonic codes.

d. Parameter Name. The name of the function being recorded. The documentation must contain a means to correlate each recorded parameter name to those in the applicable appendix (part 121, appendix B or M; part 125 appendix E; or part 135, appendices B through F). Where possible, the parameter name should correlate to the aircraft manufacturer's interface control documentation. Sufficient information must be contained in the parameter name to make it unique and to convey information on its source.

e. Range. The full range of a parameter (minimum to maximum) expressed in engineering units (E.U.). Where the parameter range accommodated in the aircraft exceeds the parameter range specified in the regulations, (e.g., pressure altitude in large aircraft) the applicant should provide for recording the range accommodated in the aircraft. Enter N/A for discrete parameters.

f. Signal Source. The aircraft subsystem, or the dedicated transducer or signal conditioner, installed primarily to provide the signal for the DFDR, FDAU, or DFDAU (or equivalent).

g. Superframe Cycle. A subdivision of a given word slot address in a subframe. This typically provides 16 additional addresses. A counter provides the cycle number reference. The cycle number must be documented as a parameter.

h. Word Slot. The location of a 12-bit word within the subframe.

2. Data Stream Format. The data stream format defines where an analyst must look in the DFDR output to find a selected parameter or other information. Most DFDR data are encoded using the specifications of ARINC 573 or ARINC 717. Although these ARINC data bus encoding systems do not specify the date format, they provide the framework within which the data is formatted. They generate 64 12-bit words per second yielding a bit rate of 768 bits per second. The word rate may vary in multiples of two, i.e. 32, 64, 128, 256, or 512. The data is organized into frames that are repeated every four seconds. Each frame consists of four subframes that occupy one second each in the data stream. The first word in each subframe normally provides the frame synchronization pattern. The data stream format should enable the analyst to locate header information and parameter information in the DFDR output.

APPENDIX 1. STANDARD DATA FORMAT FOR DIGITAL FLIGHT DATA RECORDERS DATA STREAM FORMAT AND CORRELATION DOCUMENTATION (CONTINUED)

a. Header Information. For DFDR's that conform to ARINC specifications, the following information must be stored in a header file. For other DFDR frame structures, the number of subframes per frame must be omitted and the frame structure must be uniquely described.

(1) Aircraft Make and Model.

(2) Aircraft Serial Number.

(3) DFDR Make and Model/Part Number.

(4) Number of subframes per frame.

b. Record Information. The following information must be provided for each record; except that if each subframe is identical, it may be provided only once:

(1) Bits in the DFDR Word.

(2) Number of DFDR Words in a Subframe.

(3) Time duration of the subframe (seconds).

c. Parameter Information. The identification for each parameter must include:

(1) Parameter Name – must be unique from all other parameters recorded.

(2) Mnemonic Code – a common abbreviation for the parameter.

d. Parameter Location. Both component(s)and timing information must be provided for each parameter sample. Usually there is only one component. For samples having more than one component the components must be ordered from least significant to most significant in the data stream. Each sample location for a parameter must have the same total number of bits. The following items must be provided for a parameter sample location:

(1) Subframe Number.

(2) Word Number.

(3) Bit Numbers.

(4) If superframe cycles are used, also provide:

APPENDIX 1. STANDARD DATA FORMAT FOR DIGITAL FLIGHT DATA RECORDERS DATA STREAM FORMAT AND CORRELATION DOCUMENTATION (CONTINUED)

(a) Cycle counter name.

(b) Cycle numbers.

3. Lexicon of Mnemonic Codes. If mnemonic codes are used, a lexicon of these codes must be provided.

4. Engineering Unit (E.U.) Conversion. Engineering unit (E.U.) conversions must convert decimal counts to the parameter value measured. Where the parameter is used by the pilot in flight (e.g. airspeed, altitude, and heading), the conversion must be correlated to the value shown to the pilot. Other values must be correlated to values sensed by the aircraft. Where an E.U. conversion results in an interim parameter (e.g., ac voltage ratio No.1, frequency, dc voltage ratio No.2, potentiometer, or synchro angle) the conversion formula that converts this interim parameter to the actual parameter must also be provided. Each recorded parameter must be converted to an E.U. Both signage (whether or not the raw data contains a plus or minus sign and the location of the sign in the parameter bits) and raw data range must be provided. Standardized signage is provided in Table 1-1. Instructions must be provided to enable the accident investigator to convert the recorded data to E.U.

Table 1-1. Standardized Sign Convention

Parameter	Sign
Aircraft Pitch Attitude – Aircraft Nose Up (ANU)	+
Aircraft Roll Attitude – Right Wing Down (RWD)	+
Flight Control Surface – Trailing Edge Up (TEU)	+
Acceleration	See Section 7.1, ARINC 717-9
Glide Slope – Fly Up Indication	+
Localizer – Fly Left Indication	+

Acceptable conversion equations are as follows:

a. Linear Equation:

$$E.U. = A_0 + A_1 * CNTS_{10}$$

where: E.U. is the value in engineering units
A_0 is the number of E.U. when the $CNTS_{10}$ equals zero
A_1 is the slope of the line in engineering units per decimal count
$CNTS_{10}$ is the number of binary or binary coded decimal counts

converted to decimal counts

APPENDIX 1. STANDARD DATA FORMAT FOR DIGITAL FLIGHT DATA RECORDERS DATA STREAM FORMAT AND CORRELATION DOCUMENTATION (CONTINUED)

b. Piece-wise Linear Equation. In some instances it may be necessary to correlate the data using multiple linear equations. For example: the data of Figure 1-1. was obtained using two linear equations as follows:

For Altitude (E.U.) $\leq$ 500 feet	For Altitude (E.U.) > 500 feet
$A_0 = (-0.002)$	$A_0 = (-0.29673)$
$A_1 = (0.200231)$	$A_1 = (0.013351)$

where: $\leq$ indicates equal to or less than
$>$ indicates greater than

c. Polynomial Equation.

$$E.U. = A_0 + A_1 * CNTS_{10} + A_2 * CNTS_{10}^2 + \ldots A_x * CNTS_{10}^x$$

where: E.U. is the value in engineering units
$CNTS_{10}$ is the number of binary or binary coded decimal counts converted to decimal counts
A_0 is the number of E.U. when the $CNTS_{10}$ equals zero
$A_1, A_2, \ldots A_x$ are coefficients developed by a curve fit

d. Unique Equation. Where a unique equation applies, explicit documentation must be developed at the time of certification, and approved by the FAA.

5. E.U. Data Correlation. An acceptable procedure to correlate the recorded data to the data derived from the conversion equation follows:

a. Set or read the device being measured (radio altimeter altitude for example) to a known fixed data point.

b. Record the data in the Raw Data (E.U.) column of the Correlation Table 1-3.

c. Record the decimal counts from the DFDR record in the $CNTS_{10}$ column of the Correlation Table (See Table 1-3).

APPENDIX 1. STANDARD DATA FORMAT FOR DIGITAL FLIGHT DATA RECORDERS DATA STREAM FORMAT AND CORRELATION DOCUMENTATION (CONTINUED)

NOTE: The DFDR normally records counts in a binary format. Most equipment manufacturers provide a digital output port and test equipment to access the data. Data can be displayed in either binary, octal, or hexadecimal format with octal being the most common. Convert the counts to decimals using instructions provided by the equipment manufacturer.

d. Repeat steps 1 through 3 above until a sufficient number of data points have been collected for correlation.

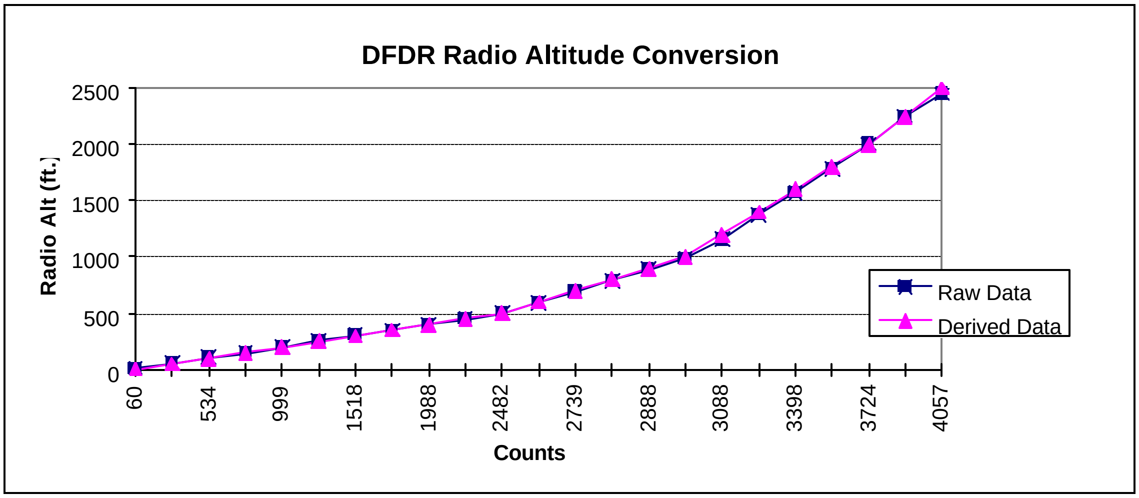
Note: The number of required data points will vary depending upon the parameter and the transducer. As a minimum, three data points must be recorded for linear equation parameters, one at the mid-point (or null point) and the others at each end point of the range for the parameter. A minimum of six data points must be recorded for polynomial equation parameters For piece-wise linear equations, a minimum of three data points must be recorded for each linear segment of the equation.

e. Derive the E.U. value for each recorded $CNTS_{10}$ value using the conversion equation or method provided. Record the derived value for each data point.

f. The tabulated raw data and the derived data must also be plotted to confirm the prediction capability of the equation (linear, piece-wise linear, polynomial or unique). The plot must cover the full operating range for the parameter. See Figure 1-1 for an example plot. In the example of Figure 1-1, the data is so closely correlated (correlation coefficient = 0.99985) that the raw data and the derived data appear to be superimposed on each other.

APPENDIX 1. STANDARD DATA FORMAT FOR DIGITAL FLIGHT DATA RECORDERS DATA STREAM FORMAT AND CORRELATION DOCUMENTATION (CONTINUED)

Figure 1-1. An Example Plot of the Radio Altimeter in Feet Versus Decimal Counts



6. Discrete Decipher Logic: The correlation documentation must contain decipher logic for discrete parameters. The decipher logic must identify the status of the discrete represented by each binary state (e.g., “0” =OFF, “1”=ON). In instances where a group of discrete states is represented by multiple binary bits, the entire discrete word must be presented in the correlation document. See Table 1-2. The word slot, subframe, and bit logic for the specific discrete codes must be identified in the documentation

Table 1-2. Example of Grouped Discrete Codes Decipher Logic

Word Slot ______________ Subframe ____________________							
Discrete Status	**Discrete Codes**						
	7	6	5	4	3	2	1
A/P Mode Throttle “OFF”	1	1	0	0	0	0	0
A/P Mode Throttle “RETARD”	1	1	0	0	0	0	1
A/P Mode Throttle “CLAMP”	1	1	0	0	0	1	0
A/P Mode Throttle “SPD/MCH,ALPHA”	1	1	0	0	0	1	1
A/P Mode Throttle “SPD/MCH,FLAP”	1	1	0	0	1	0	0
A/P Mode Throttle “SPD/MCH,SLAT”	1	1	0	0	1	0	1
A/P Mode Throttle “SPEED”	1	1	0	0	1	1	0
A/P Mode Throttle “EPR LIMIT”	1	1	0	0	1	1	1
A/P Mode Throttle “SPD/EPR LIMIT”	1	1	0	1	0	0	0

7. Validation of Engineering Unit Correlation: Calculate the correlation coefficient between the raw data and the derived data. Table 1-3 may be used to aid this calculation. The correlation coefficient must be calculated as follows:

APPENDIX 1. STANDARD DATA FORMAT FOR DIGITAL FLIGHT DATA RECORDERS DATA STREAM FORMAT AND CORRELATION DOCUMENTATION (CONTINUED)

$$r = \frac{N * \Sigma(x*y) - \Sigma x * \Sigma y}{\{ [N * \Sigma x^2 - (\Sigma x)^2] * [N * \Sigma y^2 - (\Sigma y)^2] \}^{1/2}}$$

where:
r = correlation coefficient
N = number of data points
x = raw data (E.U.)
y = derived data (E.U.)
Σ indicates the sum of the values that follow (e.g., Σx equals the sum of all x values)

Table 1-3 Correlation Table Decimal Counts to Engineering Units

Parameter No. ____ **Parameter** ______________________________________

Conversion Method ☐ **Linear** ☐ **Polynomial** ☐ **Unique**

A_0 ____________ **Unique Equation Reference:**__________
A_1 ____________ ______________________________________
A_2 ____________
A_3 ____________
A_4 ____________
A_5 ____________

Data Point No.	Raw Data (E.U.)	$CNTS_{10}$	Derived Value (E. U.)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

APPENDIX 1. STANDARD DATA FORMAT FOR DIGITAL FLIGHT DATA RECORDERS DATA STREAM FORMAT AND CORRELATION DOCUMENTATION (CONTINUED)

Table 1-4 Correlation Coefficient Calculation

Parameter No. ____

Parameter Name ________________________________
Mnemonic Code _____________
Parameter Word Location ___________________
Subframe _______________
Superframe Cycle ___________________
Assigned Bits (1 through 12) __________________
Range (E.U.) ______________________
Sign Convention ______________________________
Correlation Coefficient _________

Data Point No.	***x Raw Data (E.U.)***	***y Derived Value (E.U.)***	***x^2***	***y^2***	***x * y***
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
N =	Σx =	Σy =	Σx^2 =	Σy^2 =	Σ(x*y) =

a. N * Σ(x*y) = __________

b. $\Sigma x * \Sigma y$ = __________

APPENDIX 1. STANDARD DATA FORMAT FOR DIGITAL FLIGHT DATA RECORDERS DATA STREAM FORMAT AND CORRELATION DOCUMENTATION (CONTINUED)

c. Subtract (b) from (a)
$N * \Sigma(x*y) - \Sigma x * \Sigma y =$ ____________

d. $N * \Sigma x^2 =$ __________

e. Square the sum of x (Σx) and subtract this square from (d)
$[N * \Sigma x^2 - (\Sigma x)^2] =$ (4) - Column 4 = __________

f. $N * \Sigma y^2 =$ ___________

g. Square the sum of y (Σy) and subtract this square from (f)
$[N * \Sigma y^2 - (\Sigma y)^2] =$ __________

h. Subtract (g) from (f)
$[N * \Sigma x^2 - (\Sigma x)^2] * [N * \Sigma y^2 - (\Sigma y)^2] =$ ____________________

i. Take the square root of (h)
$\{ [N * \Sigma x^2 - (\Sigma x)^2] * [N * \Sigma y^2 - (\Sigma y)^2]\}^{1/2} =$ ____________________

j. Divide (c) by (i)

$$r = \frac{N * \Sigma(x*y) - \Sigma x * \Sigma y}{\{ [N * \Sigma x^2 - (\Sigma x)^2] * [N * \Sigma y^2 - (\Sigma y)^2] \}^{1/2}} = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_$$

The correlation coefficient (r) must not be less than 0.9

TABLE 1-5. Typical Lexicon of Mnemonic Codes

CODE	**PARAMETER**
AOA	Angle of Attack
CAS	Calibrated Airspeed
ANU	Aircraft Nose Up
TEU	Trailing Edge UP
SPD	Speed
A/P	Autopilot
EPR	Engine Pressure Ratio
THRTL	Throttle
MCH	MACH

RWD	Right Wing Down

APPENDIX 2. DIGITAL FLIGHT DATA RECORDER REQUIREMENTS SCHEDULE

1. Turbine-engine powered transport category airplanes operating under the provisions of 14 CFR part 121. For scheduling of DFDR system installations, there are six categories of turbine-engine powered transport category airplanes. Affected airplanes in the first four categories are those requiring post-production retrofits. The other two categories include airplanes that will receive the system during production. Airplanes requiring retrofit are grouped by the date of manufacture and by the particular equipment installed at the time the DFDR Notice of Proposed Rule Making was published (July 16, 1996). Airplanes upgraded during production are grouped by manufacture dates. The categories are as follows:

a. Airplanes manufactured on or before October 11, 1991, that were *not* equipped with Flight Data Acquisition Units (FDAU) as of July 16, 1996. These airplanes must be upgraded from their current eleven (11) parameter recording capability to record eighteen (18) parameters. The retrofit must be accomplished by the next heavy maintenance check after August 18, 1999, but no later than August 20, 2001.

(1) The parameters must be recorded to the range and accuracy specifications of part 121. appendix B (or part 125, appendix D).

(2) Recording of lateral acceleration, parameter (18), for airplanes having more than two engines is not required unless sufficient capacity is available on the installed recorder.

(3) Because of capacity limitations of some DFDR's, certain split flight control parameters (e.g., aileron, split elevator, rudder) may be recorded using the bellcrank or a single control wheel/column or pedal position instead of recording the position of both control wheel/column or sets of rudder pedals. The following parameters may be recorded from a single source. However, sensors must be located so as to allow for the differentiation between cockpit flight control inputs and flight control surface position:

(a) Parameter (12) Pitch control input.

(b) Parameter (13) Lateral control input.

(c) Parameter (14) Rudder pedal input.

(d) Parameter (15) Primary pitch control surface position.

(e) Parameter (16) Primary lateral control surface position.

(f) Parameter (17) Primary yaw control surface position.

APPENDIX 2. DIGITAL FLIGHT DATA RECORDER REQUIREMENTS SCHEDULE (CONTINUED)

b. Airplanes manufactured on or before October 11, 1991, that were equipped with FDAU as of July 16, 1996. These airplanes must be upgraded to record 22 parameters. The retrofit must be accomplished by the next heavy maintenance check after August 18, 1999, but no later than August 20, 2001.

(1) The parameter specifications of 14 CFR part 121, appendix M or 14 CFR part 125, appendix E apply to all parameters.

(2) Because of capacity limitations of some DFDR's, certain split flight control parameters may be recorded using the bellcrank or a single control wheel/column or pedal position instead of recording the position of both control wheel/column or sets of rudder pedals. The following parameters may be recorded from a single source. However, sensors must be located so as to allow for the differentiation between cockpit flight control inputs and flight control surface position:

(a) Parameter (12) Pitch control input.

(b) Parameter (13) Lateral control input.

(c) Parameter (14) Rudder pedal input.

(d) Parameter (15) Primary pitch control surface position.

(e) Parameter (16) Primary lateral control surface position.

(f) Parameter (17) Primary yaw control surface position.

c. Airplanes manufactured on or before October 11, 1991, that were equipped with ARINC 717 DFDAU or equivalent as of July 16, 1996. These airplanes must be upgraded to record 22 parameters. The retrofit must be accomplished by August 20, 2001.

(1) The parameter specifications of part 121, appendix M, or part 125, appendix E apply to all parameters.

(2) Because of capacity limitations of some DFDR's, certain split flight control parameters
(e.g., pitch control input, lateral control input, and rudder pedal input) may be recorded using the bellcrank or a single control wheel/column or pedal position instead of recording the position of both control wheel/column or sets of rudder pedals. The following parameters may be recorded from a single source. However, sensors must be located so as to allow for the differentiation between cockpit flight control inputs and flight control surface position:

APPENDIX 2. DIGITAL FLIGHT DATA RECORDER REQUIREMENTS SCHEDULE (CONTINUED)

(a) Parameter (12) Pitch control input.

(b) Parameter (13) Lateral control input.

(c) Parameter (14) Rudder pedal input.

(3) Additional parameters must be recorded if the capacity of the recording system permits. The recording system refers to the already installed DFDAU and DFDR plus any necessary DFDAU and DFDR installed in order to record parameters (1) through (22). This requirement only applies if the data source is already installed and connected to the recording system. For example, if a ground proximity warning system is already installed in the airplanes and the wiring is in place to connect it to the DFDAU and the DFDR system has sufficient available recording capacity (data bit stream slots and memory), then parameter (35), ground proximity warning system, must be recorded. Where a choice is available, the applicant should select additional parameters to be recorded in priority order if practical. Keeping in mind the generic form of the parameter listing, it may be appropriate to deviate from the order of the parameter list to record a non-mandatory parameter or parameters to monitor an operational or system characteristic unique to that make and model airplane.

(4) All airplanes equipped with ARINC 717 DFDAU that were required to have a DFDR system installed by section 121.343(e) or 125.225(e) must continue to comply with section 121. 343(e) or 125.225(c) until they are retrofitted.

d. <u>Airplanes manufactured after October 11, 1991, but before August 18, 2000</u>. These airplanes must be upgraded to record 34 parameters. The retrofit must be accomplished by August 20, 2001.

(1) The parameter specifications of part 121, appendix M (part 125, appendix E) apply to all parameters.

(2) Because of capacity limitations of some DFDR's, certain split flight control parameters (e.g., pitch control input, lateral control input, and rudder pedal input) may be recorded using the bellcrank or a single control wheel/column or pedal position instead of recording the position of both control wheel/column or sets of rudder pedals. The following parameters may be recorded from a single source. However, sensors must be located so as to allow for the differentiation between cockpit flight control inputs and flight control surface position:

(a) Parameter (12) Pitch control input.

(b) Parameter (13) Lateral control input.

APPENDIX 2. DIGITAL FLIGHT DATA RECORDER REQUIREMENTS SCHEDULE (CONTINUED)

(c) Parameter (14) Rudder pedal input.

(3) Additional parameters must be recorded if the capacity of the recording system permits. The recording system refers to the already installed DFDAU and DFDR plus any necessary DFDAU and DFDR installed in order to record parameters (1) through (34). This requirement only applies if the data source is already installed and connected to the recording system. For example, if a ground proximity warning system is already installed in the airplanes and the wiring is in place to connect it to the DFDAU and the DFDR system has sufficient available recording capacity (data bit stream slots and memory), then parameter (35) must be recorded. Where a choice is available, the applicant should select the additional parameters to be recorded in priority order if practical. Keeping in mind the generic form of the parameter listing, it may be appropriate to deviate from the order of the parameter list to record a non-mandatory parameter or parameters to monitor an operational or system characteristic unique to that make and model airplane.

e. Airplanes manufactured after August 18, 2000, but before August 20, 2002. The airplanes must be equipped to record 57 parameters.

(1) The parameter specifications of part 121, appendix M or part 125, appendix E applies to all parameters.

(2) Additional parameters must be recorded if the capacity of the recording system permits. The recording system refers to the already installed DFDAU and DFDR plus any necessary DFDAU and DFDR installed in order to record parameters (1) through (57). This requirement only applies if the data source is already installed and connected to the recording system. For example, if a ground proximity warning system is already installed in the airplane and the wiring is in place to connect it to the DFDAU and the DFDR system has sufficient available recording capacity (data bit stream slots and memory), parameter (35) must be recorded. Where a choice is available, the applicant should select the additional parameters to be recorded in priority order, if practical. Keeping in mind the generic form of the parameter listing, it may be appropriate to deviate from the order of the parameter list to record a non-mandatory parameter or parameters to monitor an operational or system characteristic unique to that make and model airplane.

f. Airplanes manufactured after August 19, 2002. These airplanes must be equipped to record 88 parameters. The parameter specifications of part 121, appendix M, or part 125, appendix E, apply to all parameters.

2. Turbine-engine powered airplanes having passenger seating of 10 to 19 seats operating under the provisions of 14 CFR part 121. There are three categories of 10 to 19 passenger airplanes for scheduling of DFDRS installations.

APPENDIX 2. DIGITAL FLIGHT DATA RECORDER REQUIREMENTS SCHEDULE (CONTINUED)

a. Airplanes (10 to 19 passengers) brought onto the U. S. register or foreign-registered airplanes added to an operator's U. S. operations specifications after October 11, 1991, but manufactured on or before August 18, 2000. In order to operate under part 121, these airplanes must be equipped with a DFDR system recording 18 parameters by the next heavy maintenance check or equivalent after
August 18, 1999, but before August 20, 2001. The parameter specifications of part 135, appendix B applies to all parameters. Where part 135, appendix B does not provide a specification (range, accuracy or sampling interval) the specification of appendix M must be used. In order to operate under part 135, these airplanes must be equipped with a 25 hour DFDRS that record parameters listed in part 135, appendix B.

(1) Only one parameter in each of the following parameter pairs need be to recorded:

(a) Parameter (12), or parameter (15).

(b) Parameter (13), or parameter (16).

(c) Parameter (14), or parameter (17).

(2) Recording of lateral acceleration for airplanes having three or more engines is not required unless sufficient capacity is available on the installed recorder.

(3) Because of parameter capacity limitations of the modified DFDR, certain split flight control parameters (e.g., aileron, split elevator) may be recorded using the bellcrank or a single surface or pedal position instead of recording the position of both surfaces or pedals. The following parameters may be recorded from a single source:

(a) Parameter (12), Pitch control input.

(b) Parameter (13), Lateral control input.

(c) Parameter (14), Rudder pedal input.

(d) Parameter (15), Primary pitch control surface position.

(e) Parameter (16), Primary lateral control surface position.

(f) Parameter (17), Primary yaw control surface position.

(4) If the FDAU and the DFDR have the capacity to record additional parameters, the following parameters must be selected for recording in the order listed:

APPENDIX 2. DIGITAL FLIGHT DATA RECORDER REQUIREMENTS SCHEDULE (CONTINUED)

(a) Parameter (19), Pitch Trim Position or Parameter (82), Cockpit Trim Control Input Position - Pitch.

(b) Parameter (20), Trailing Edge Flap or Cockpit Flap Control Selection.

(c) Parameter (21), Leading Edge Flap or Cockpit Flap Control Selection.

(d) Parameter (22), Each Thrust Reverser Position (or equivalent for propeller airplane).

b. Airplanes (10 to 19 passengers) manufactured after August 18, 2000, but before August 20, 2002. These airplanes operated under part121 must be equipped with a DFDRS that records 57 parameters. The parameter specifications of part 121, appendix M applies to all parameters. Additional parameters must be recorded if sufficient recording capacity exists in the DFDRS.

c. Airplanes (10 to 19 passengers) manufactured after August 19, 2002. These airplanes must be equipped with the 88-parameter system. The parameter specifications of part 121, appendix M applies to all parameters.

3. Airplanes (10 to 30 passengers) operated under part 135 and manufactured after August 18, 2000, but before August 20, 2002. These airplanes operated under part 135 must be equipped with a 57-parameter DFDRS by August 20, 2001. The parameter specifications of part 135, appendix F applies to all parameters. Additional parameters must be recorded if sufficient recording capacity exists in the DFDRS.

4. Airplanes (10 to 30 passengers) operated under Part 135 and manufactured after August 19, 2002. These airplanes, operated under part 135, must be equipped with the 88 parameter system. The parameter specifications of 14 CFR part 135 appendix F applies to all parameters.

5. Multiengine turbine-powered 10 to 19 passenger rotorcraft brought onto the U.S. register or registered outside the United States and brought onto an operators U.S. operations specification after October 11, 1991. These rotorcraft must be upgraded to a 25-hour DFDRS that must record the parameters listed in part 135, appendix H.

6. Stage 2 airplanes that are subject to section 91.801(c) until January 1, 2000. If these airplanes are allowed to continue operating on or after January 1, 2000, they must, at that time,

comply with the applicable DFDRS requirements of section 121.344 in order to continue operation.

APPENDIX 2. DIGITAL FLIGHT DATA RECORDER REQUIREMENTS SCHEDULE (CONTINUED)

7. U.S. registered aircraft operated by a foreign carrier under part 129. These aircraft must have a DFDRS that records the parameters that would be required under part 121, 125, or 135 as applicable to the aircraft.

8. Airplanes not required to have a DFDR. The following airplanes manufactured before August 18, 1997, when operated under part 121 are not required to have a DFDR but must continue to comply with the DFDR requirements of §121.343 or §135.152 as applicable:

Beech 99 series	Beech 1300
Beech 1900C	CASA C-212
*Convair 580	*Convair 600
*Convair 640	ΦdeHavilland DHC-6
*deHavilland DHC-7	Dornier 228
Embraer EMB 110	Fairchild Airplanes SA-226
*Fairchild Industries FH227	*Fokker F-27 (except Mark 50)
*Fokker F-28 Mark 1000 and Mark 4000	*Gulfstream Aerospace G-159
Hawker Siddley HS-748	Jetstream 3101 and 3201
*Maryland Air Industries F27	*Mitsubishi YS-11
*Short Bros. SD3-30 and SD3-60	Fairchild SA-226
*Lockheed Electra 10-A, 10-B, 10-E, and L-188	

Any airplane that meets the Stage 2 noise levels of part 36 and is subject to section 91.801(c) may continue to operate in compliance with Section 121.343 until January 1, 2000.

* Indicates that, when operated under part 125, these aircraft need not comply with the DFDRS requirements of section 125.226, but must continue to comply with those of section 125.225.

Φ Indicates that, these aircraft manufactured before August 18, 1997, when operated under part 135, need not comply with section 135.152. Aircraft manufactured on or after that date must comply.

APPENDIX 3. TYPICAL CERTIFICATION BASIS FOR DFDR RETROFIT

14 CFR, Section—General	14 CFR Part 23 Section	14 CFR Part 25 Section	14 CFR Part 27 Section	14 CFR Part 29 Section	Subject	Comment
21.97					Approval of major changes in type design	Substantiating data and descriptive data
21.305(b)					Approval of materials, parts, and appliances	Use for TSO approved equipment
	23.25	25.25	27.25	29.25	Weight Limits	Weight & Balance
		25.27	27.27	29.27	Center-of-gravity limits	Weight & Balance
	23.603	25.603	27.603	29.603	Materials	Use of TSO approved equipment
	23.1359(c)	25.869(a)(4)	27.1365(c)	29.1359(c)	Fire Protection: Systems	Insulation on electrical wire must be self-extinguishing
	23.1301(a)	25.1301(a)	27.1301	29.1301	Function and installation	Appropriate for intended function
	23.1301(b)	25.1301(b)				Labeled for identification
	23.1301(c)	25.1301(c)				Installed according to limitations
	23.1301(d)	25.1301(d)				Parameter correlation test and documentation
	23.1309(b)(1)	25.1309(a)	27.1309	29.1309	Equipment, systems, and installations	Foreseeable operating conditions
	23.1309(b)(2)	25.1309(b)				Failure conditions
	23.1309(b)(3)	25.1309(c)				Warning information

APPENDIX 3. TYPICAL CERTIFICATION BASIS FOR DFDR RETROFIT (CONTINUED)

14 CFR, Section—General	14 CFR Part 23 Section	14 CFR Part 25 Section	14 CFR Part 27 Section	14 CFR Part 29 Section	Subject	Comment
	23.1309(c)	25.1309(e)				Electrical loads analysis - power loads in probable operating conditions and durations
	23.1309(e)	25.1309(g)				Critical environmental conditions
	23.1351(a)	25.1351(a)	27.1351	29.1351	Electrical Systems and Equipment, General	Electrical loads analysis
	23.130(c)	25.1353(a)	27.1365		Electrical systems and installations	Does not adversely affect simultaneous operation
	23.1365	25.1353(b)				Cables, damage to essential circuits
	23.1357	25.1357(a)		29.1357	Circuit protective devices	Circuit breakers, wiring faults, and system malfunctions
	23.1431	25.1431(a)		29.1431	Electronic equipment	Critical environmental conditions
	23.1437	25.1431(b)				Independent sources of power
	23.1431(b)	25.1431(c)				Adverse effect on other equipment
	23.1459(a)(1)	25.1459(a)(1)	27.1459	29.1459	Flight recorders	Airspeed, altitude, and directional data
	23.1459(a)(2)	25.1459(a)(2)				Vertical acceleration sensor
	23.1459(a)(3)	25.1459(a)(3)				Electrical power
	23.1459(a)(4)	25.1459(a)(4)				Aural and visual means of preflight check
	23.1459(a)(5)	25.1459(a)(5)				Automatic means to stop

APPENDIX 3. TYPICAL CERTIFICATION BASIS FOR DFDR RETROFIT (CONTINUED)

14 CFR, Section—General	14 CFR Part 23 Section	14 CFR Part 25 Section	14 CFR Part 27 Section	14 CFR Part 29 Section	Subject	Comment
		25.1459(a)(6)				Time of each radio transmission
	23.1459(b)	25.1459(b)				Located and mounted
	23.1459(c)	25.1459(c)				Correlation Performed to Section 121.344(j) under intended function to operating rule.
	23.1459(d)(1)	25.1459(d)(1)				Bright orange
	23.1459(d)(2)	25.1459(d)(2)				Reflective tape
	23.1459(d)(3)	25.1459(d)(3)				ULD
	23.1459(e)	25.1459(e)				Novel or unique characteristics
	23.1529	25.1529	27.1529	29.1529	Instructions for continued airworthiness	Description, servicing, troubleshooting, testing, and repair

APPENDIX 4. TYPICAL FLIGHT SEQUENCE DATA RECORD FOR TYPE INSPECTION FLIGHT TEST - 36 PARAMETER DFDRS INSTALLATION

1. Begin recording prior to takeoff. Record:

   a. Prior to takeoff record time of flight control check (hold flight controls at full travel for 2 to 5 seconds, each position).
   b. Takeoff Flap Setting.
   c. Takeoff thrust setting.
   d. Brake release time.
   e. Rotation Speed (V_R) and time of rotation.
   f. Aircraft attitude after rotation.

2. During stabilized climb (wings level) after takeoff record:

   a. Altitude and time at which climb stabilized.
   b. Airspeed.
   c. Vertical speed.
   d. Pitch attitude.
   e. Displayed angle of attack.
   f. Heading (note true or magnetic).

3. During Level Flight (wings level) at maximum operating limit speed (V_{MO}./M_{MO}) or at V_{MAX} record:

   a. Altitude and time at start of level flight.
   b. Airspeed.
   c. Ground speed and time at which recorded (three times).
   d. Outside or total air temperature.
   e. Automatic Flight Control System (AFCS) Mode and engagement status including autothrottle.
   f. Pitch attitude.
   g. Displayed angle of attack.
   h. Heading (note true or magnetic).
   i. Drift angle and time at which recorded (three times).
   j. All displayed engine performance parameters for each engine.
   k. Altitude and time at end of level flight.

4. During a banked turn (90^o to 180^o heading change) record:

   a. Altitude, heading and time at beginning of turn.
   b. Stabilized roll attitude (bank angle).
   c. Altitude, heading and time at end of turn.

APPENDIX 4. TYPICAL FLIGHT SEQUENCE DATA RECORD FOR TYPE INSPECTION FLIGHT TEST - 36 PARAMETER DFDRS INSTALLATION (CONTINUED)

5. During stabilized (wings level) descent, record:

   a. Altitude and time at which descent initiated.
   b. Airspeed.
   c. Pitch attitude.
   d. Displayed angle of attack.
   e. Heading (note true or magnetic).
   f. Altitude and time at which leveled off.

6. During approach at level flight (wings level) deploy flaps throughout the flap operating range in all available settings (or at 5^o increments) and hold for 5 seconds at each setting. Record:

   a. Altitude and time at beginning of flap deployment sequence.
   b. Flap setting and time when each setting is reached.
   c. Altitude and time at end of flap deployment sequence.

7. During final approach, record:

   a. Altitude and time at beginning of final.
   b. Radio altitude and time at which recorded (three points).
   c. Localizer Deviation and time at which recorded (three times).
   d. Glide Slope Deviation and time at which recorded.
   e. Time of Outer Marker passage.
   f. Time of Landing Gear Deployment.
   g. Final flap setting.
   h. Time of Inner Marker passage.

8. During landing and rollout, record:

   a. Time when thrust reversers deployment sequence was initiated.
   b. Ground spoiler or speed brake setting and time ground spoiler deployed.

9. During all flight phases, record:

   a. Time of any three radio transmissions from each flightcrew position.
   b. Any warning or caution lights that illuminated and the time at which they illuminated.

APPENDIX 5. TYPICAL REASONABLENESS AND QUALITY CHECK INSTRUCTIONS

1. General. The operator must accomplish a reasonableness and quality check of the recorded flight data to ascertain that the data is being recorded correctly and that noise and data dropouts do not interfere with the ability to interpret the recorded data. The check may be performed using data that is in electronic format or using hardcopy data. If a hardcopy printout is used, data traces should also be available. The check must be performed using data that has been extracted in engineering units. Octal, binary coded decimal, or hexadecimal coded data does not provide the analyst a clear understanding of how the parameters are varying and how they are correlated to each other.

2. Checklist. The analyst must use a checklist to assure that all necessary checks have been accomplished. The checklist must refer the analyst to troubleshooting or repair procedures should a suspect parameter be identified.

3. Functional Checks. The reasonableness and quality check is only a part of the checks needed in order to ascertain that flight data is being properly recorded. The analyst should also perform functional checks of parameters that were not exercised during the period(s) of flight from which the stored data was extracted. The operator may include a check of recorded flight data during a systems check of the system providing the data. Or, the operator may include a functional exercise of the system and a flight data extraction during the reasonableness and quality check. The objective is to ensure that all parameters are checked periodically; either at the frequency that the recorded flight data is checked or at the frequency at which the system that provides the data is checked. Some examples of parameters that do not change during a typical flight are: Fire Warning Discrete, Master Warning Discrete, and Hydraulic Pressure Low.

4. Flight Segment Selection. The data to be used by the analyst should be extracted from both the takeoff and the landing phase of flight. During the cruise segment of a flight the parameters remain steady, and therefore movement of related parameters cannot be correlated. The takeoff and landing segments of flight provide the analyst an opportunity to observe data that is changing as the aircraft climbs, descends, accelerates, decelerates, and banks or turns. Furthermore, many parameters that are not exercised during the cruise segment are exercised during the takeoff and landing segments.

5. Sign Conventions. Each aircraft has a pre-established sign convention for the direction of movement of its flight control surfaces. It is imperative that the analyst be able to confirm proper direction of movement and not just verify movement. Therefore, the sign convention should be included in the checklist or the analyst should review the assigned sign conventions before beginning the check.

6. Failed Parameters. The analyst should examine the extracted data to determine if parameters that normally vary in flight, e.g. flight controls, flight control surface positions, and heading, are indeed varying. Pegged or unmoving parameter values are

indications of an inoperative sensor or other failure. Accelerometers tend to fail in the "pegged" position. If the accelerometer trace is unmoving throughout all segments of flight checked, check to see if it indicates maximum or minimum acceleration. An accelerometer failure indicating a mid-point value is uncommon.

7. Correlation to Other Parameters. The reasonableness check should include a check of the correlation between parameters that depend upon each other. For example: if ROLL increases, a turn is indicated and HEADING should begin to change soon after the increase is detected. Also, AILERON POSITION and CONTROL WHEEL POSITION should have changed immediately before the ROLL increase. One may even note a variation in LATERAL ACCELERATION.

Again, it should be emphasized that movement is indicated in the proper direction according to the aircraft sign convention. Table 5-1 is provided as an aid in preparing a reasonableness checklist. It summarizes parameters in a 34-parameter Digital Flight Data Recorder System that may be expected to interact. A check mark (✓) in a block indicates that the parameter identified in the row and the parameter identified in the column are interdependent at some time during takeoff and climb or approach and landing. Therefore, the movement of one parameter should cause or be caused by movement in the other. The following examples show how to use Table 5-1 in developing a reasonableness checklist for each parameter.

a. Thrust Reverser Position Reasonableness and Quality Check. The column labeled Thrust Reverser Position contains check marks in the rows labeled airspeed, engine thrust, longitudinal acceleration, autopilot AFCS mode, and air/ground sensing. In preparing the checklist, one would normally expect the thrust reverser to deploy during rollout after landing. Thus, the following checklist might be developed using the parameters identified by a check mark.

(1) Examine the thrust reverser in-transit and the thrust reverser deployed data to determine that they indicate in-transit only for a short period during the landing roll and deployed at the end of the in-transit period. The data should indicate in-transit and the deployed discrete should go to zero or null near the end of the landing roll.

(2) Examine the engine thrust data during the in-transit period and immediately after the deployed indication. During the in-transit period, engine thrust should have decreased to near zero and immediately after the deployed indication, the engine thrust should have increased to near the maximum indication.

APPENDIX 5. TYPICAL REASONABLENESS AND QUALITY CHECK INSTRUCTIONS (CONTINUED)

(3) Examine the airspeed and longitudinal thrust data. These two parameters should be decreasing during the in-transit period and should dramatically decrease immediately after the deployed indication.

(4) Examine the autopilot AFCS mode discrete and the air/ground sensing discrete. The autopilot AFCS mode discrete should indicate that the autopilot is disengaged and the air/ground sensing switch discrete should indicate that the aircraft is on the ground.

(5) Examine the remaining data for the thrust reverser discretes to ascertain that no in-transit or deployed indications appear. If intermittent indications appear, determine that they are within allowed values and do not have sufficient duration to be interpreted as an actual deployment and that they would not obscure an actual deployment.

b. <u>Lateral Control Surface Position Reasonableness and Quality Check</u>. The column labeled lateral control surface position contains check marks in the rows labeled heading, roll attitude, lateral control position, and localizer deviation. The lateral control surfaces are typically ailerons that are used in establishing the aircraft in a turn and returning the aircraft to straight flight from a turn. The lateral control surface position data may be checked along with the lateral control position data. These checks may be accomplished during the approach and landing segment.

(1) Examine the lateral control surface position trace for deviations during the initial approach segment. A large deviation would normally indicate the aircraft turning onto final approach heading. Check that the lateral control position and roll attitude make a large change at the same time.

(2) Check to determine that heading begins to change immediately after the lateral control surface position begins to change. Heading should continue to change after the lateral control surface position returns to the zero or null value. The heading data should begin to change at a lower rate when the lateral control surface position data moves in the opposite direction and after the lateral control position is again returned to zero or null the heading data should again be constant.

(3) Check the localizer deviation for changes. Small lateral control surface position and lateral control position data changes should accompany deviations from the localizer and returns to the localizer.

(4) Check the lateral control surface position data to determine that there are no data dropouts and that there is no noise in the data. If dropouts or noise are detected, determine that they are within allowable values and that they would not be interpreted as an actual control surface position movement.

APPENDIX 5. TYPICAL REASONABLENESS AND QUALITY CHECK INSTRUCTIONS (CONTINUED)

TABLE 5-1 PARAMETER CORRELATION

34. Ground speed	33. Hydraulic pressure low	32. Angle of attack	31. Air/ground sensing	30. Master warning	29. Marker beacon	28. Glideslope deviation	27. Localizer deviation	26. Radio altimeter	25. Autopilot, AFCS modes	24. OAT/TAT	23. Ground spoiler position	22. Thrust reverser positions	21. Leading edge flaps/slats	20. Trailing edge flaps	19. Pitch trim surface positions	18. Lateral Acceleration	17. Yaw control surface positions	16. Lateral control surface positions	15. Pitch control surface positions	14. Yaw control positions	13. Lateral control positions	12. Pitch control positions	11. Longitudinal acceleration	10. Autopilot engagement	9. Engine thrust	8. Manual microphone keying	7. Roll attitude	6. Pitch attitude	5. Vertical acceleration	4. Heading	3. Airspeed	2. Pressure altitude	1. Time	PARAMETER
																																	■	1. Time
			✓		✓		✓	✓		✓			✓	✓			✓			✓				✓	✓	✓			✓	✓	✓	■		2. Pressure altitude
✓			✓					✓			✓	✓	✓	✓	✓																■	✓		3. Airspeed
																		✓			✓						✓			■		✓		4. Heading
			✓					✓								✓			✓			✓	✓					✓	■			✓		5. Vertical acceleration
		✓				✓									✓				✓			✓						■	✓					6. Pitch attitude
							✓									✓		✓			✓						■			✓				7. Roll attitude
								✓																		■						✓		8. Manual microphone keying
✓			✓					✓				✓													■							✓		9. Engine thrust
									✓															■								✓		10. Autopilot engagement
			✓								✓	✓	✓	✓	✓	✓							■						✓					11. Longitudinal acceleration
		✓				✓									✓				✓			■						✓	✓					12. Pitch control positions
							✓											✓			■						✓			✓				13. Lateral control positions
								✓									✓			■												✓		14. Yaw control positions
		✓				✓									✓				■			✓						✓	✓					15. Pitch control surface positions
							✓											■			✓						✓			✓				16. Lateral control surface positions
								✓									■			✓												✓		17. Yaw control surface positions
																■							✓				✓		✓					18. Lateral Acceleration
						✓									■				✓			✓	✓					✓			✓			19. Pitch trim surface positions
✓													✓	■									✓								✓	✓		20. Trailing edge flaps
✓													■	✓									✓								✓	✓		21. Leading edge flaps/slats
			✓						✓			■											✓		✓						✓			22. Thrust reverser positions
✓											■												✓								✓			23. Ground spoiler position
										■																						✓		24. OAT/TAT
✓									■			✓												✓										25. Autopilot, AFCS modes
			✓		✓	✓	✓	■									✓			✓					✓	✓			✓		✓	✓		26. Radio altimeter
						✓	■	✓										✓			✓						✓					✓		27. Localizer deviation
						■	✓	✓							✓				✓			✓						✓						28. Glideslope deviation
					■			✓																								✓		29. Marker beacon
				■																														30. Master warning
			■					✓				✓											✓		✓				✓		✓	✓		31. Air/ground sensing
		■																	✓			✓						✓						32. Angle of attack
	■																																	33. Hydraulic pressure low
■									✓		✓		✓	✓											✓						✓			34. Ground speed