U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject:	Airworthiness and Operational Approval of Digital Flight Data Recorder Systems	**Date:** 12/08/08 **Initiated by:** AIR-130	**AC No:** 20-141A **Change:**

FOREWORD

This advisory circular (AC) provides Federal Aviation Administration (FAA) information on certification (design and installation) and continued airworthiness of digital flight data recorder systems (DFDRS). DFDRS provide information for an investigative authority—the National Transportation Safety Board (NTSB) in the United States—to conduct more thorough investigations of accidents and incidents. The data recorded is also available to industry to enable the prediction of trends that may be useful in determining modifications needed to avoid accidents and incidents.

This AC provides information to applicants for a Supplemental Type Certificate (STC), and to individuals who are responsible for establishing and maintaining compliance under the operating rules for digital flight data recorders (DFDR). Aircraft manufacturers who intend to install DFDRs in newly manufactured aircraft could also use this information.

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 (14 CFR). Applicants may follow alternate methods, provided the alternate method is acceptable to the 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.

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CHAPTER 1. GENERAL

1-1. PURPOSE. AC 20-141A defines terms and identifies applicable regulations. Information is provided to determine to what and to whom this AC applies.

1-2. CANCELLATION. AC 20-141, Airworthiness and Operational Approval of Digital Flight Data Recorder Systems, dated October 5, 1999, is canceled.

1-3. DEFINITIONS.

a. Applicant. An individual or organization that is seeking Federal Aviation Administration (FAA) approval for a digital flight data recorder (DFDR) installation. The approval may be a type certificate (TC), amended TC, or Supplemental Type Certificate (STC). The approval may apply to a single aircraft or to multiple aircraft of a single type design.

b. Correlation. Describes the relationship between two variables. In this case, the two variables are the raw data stored in the DFDR and its conversion into engineering units to the device being measured or the source that this raw data represents in engineering units.

c. Correlation Coefficient. A number that describes the degree of relation between the data being sampled and the data derived from the recorder. The correlation coefficient used here is the Pearson product-moment correlation coefficient, however the coefficient of determination R^2 or the sum of least squares methods are acceptable. Its value may vary from minus one to plus one. A value of positive one (1.0) indicates a perfect direct 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 negative one (-1.0) indicates a perfect inverse relationship between the derived value and the raw data. The absolute value of the correlation coefficient must be equal to or greater than 0.99 over the entire operating range of each mandatory parameter to accurately establish the conversion of recorded values to engineering units (EU). See Appendix 1 for one method, but not the only method, to determine the correlation coefficient.

d. Correlation Data. The documentation that is required by Title 14 of the Code of Federal Regulations (14 CFR) part 121, §§ 121.344(j)(3), 121.344a(d)(3), 125.226(j)(3), and 135.152(f)(2)(iii). This documentation must show how each parameter was correlated and be maintained by the operating certificate holder.

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

f. Dedicated Sources. Any digital system interface, analog discrete interface, or analog sensor interface installed solely to produce an input signal to the DFDRS. For example, if it is necessary to install a horizontally mounted accelerometer to sense lateral acceleration, then this accelerometer is considered a dedicated sensor. 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. However, the accelerometer must meet the accuracy requirements listed in the appropriate regulatory appendix.

g. Digital Flight Data Acquisition Unit (DFDAU). A DFDAU is an electronic device that collects, samples, reformats, and digitizes analog and digital signals representing aircraft flight data. See ARINC Characteristic 717. The equivalent of this function may be incorporated in other hardware which may not meet the classical definition of an ARINC 717 DFDAU.

h. Digital Flight Data Acquisition Function (DFDAF). A DFDAF is software that performs the function of a DFDAU in a larger avionics system.

i. DFDR. A recording device that uses 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 DFDAF, DFDAU, or an 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.

j. Digital Flight Data Recorder System (DFDRS). The DFDRS is the software, equipment, sensors, wiring, equipment racks, and other items installed in the aircraft to record flight data. It includes the following equipment items: DFDR, dedicated sensors, underwater locating device (ULD), and a DFDAF, DFDAU, or FDAU.

k. Dynamic Condition. The parameter is experiencing change at the maximum rate available, including the maximum rate of reversal.

l. Flight Data Acquisition Unit (FDAU). The FDAU is the predecessor to the DFDAU, defined by ARINC 573. It is primarily designed to accept analog and analog discrete input data, and in some cases, it will accept digital data on predefined inputs.

m. Flight Data Recorder (FDR). An 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 FDRs recorded the signals by scratch with a stylus on a moving oscillographic medium, 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 DFDRs be used in the U.S. commercial fleet.

n. Functional Check. A check to determine if one or more functions of a DFDRS perform within specified limits. The following identifies and defines three types of DFDRS functional checks.

(1) First of Type.

(a) The applicant must perform the first of type installation testing for an FAA approval (TC, amended TC, or STC). This check determines if the range, accuracy, sampling rate, and resolution of each parameter is within specified limits. 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. This check collects correlation data in support of certification. See Appendix 2 for procedures when a DFDR data correlation document does not exist for an aircraft.

(b) For data received by the recording system in a digital means, credit may be given to the source system in determining the range and resolution of the parameter. Range and resolution are functions, not necessarily of the recording system, but of the source system. However, the range and resolution of the source system must meet the minimum requirements of 14 CFR. If the range and resolution satisfy the requirements in 14 CFR, there is no need to repeat these checks for the purpose of meeting recording system requirements.

(c) For dedicated parameters that are analog and analog discrete in nature, all of these requirements should be checked.

(2) Operational: The 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. This may take place off the airplane.

(3) System: A system functional check confirms that interfaces to the recording system are present and functioning. This test confirms the presence of the electrical interfaces to the recording system and the function of dedicated sources. The operator must include a system functional check in the maintenance program. For dedicated sources, you may simulate sensor or transducer outputs to check the range, accuracy, sampling rate, and resolution of the recorded data. However, the instructions for continued airworthiness (ICA) and the operator's maintenance program must prescribe a periodic system functional check of each of these transducers or sensors for range and accuracy.

o. Installed and Connected to the Recording System. This refers to the requirement to record parameters in addition to those specifically identified in the regulation (i.e., 22, 34, or 57 parameters, based on the date the aircraft was manufactured; see Appendix 3). The DFDRS must record the parameters that were recorded by the aircraft'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, a previously installed DFDR must continue to record parameters it was recording effective as of July 16, 1996, plus additional parameters if they are already connected and available to the system and if capacity exists in the system to record the parameters. Thus, if a retrofitted DFDRS can accommodate additional parameters, the retrofitted DFDR 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 data bus. (See paragraph 1-3t, Sufficient Capacity.)

p. Readily Retrievable. This term means there is a method of readily retrieving data, actual sensor value of the mandatory parameter, from the storage medium by qualified personnel in 8 hours using:

(1) Existing, easily understood instructions and commonly available tools and techniques; and

(2) Step-by-step procedures, including all conversion algorithms, necessary to derive and validate the values.

NOTE: These procedures must be a permanent part of the aircraft-specific DFDRS documentation package. Portions of the documentation package pertaining to the format and conversion algorithms of the recorded data may be recorded within the crash-protected memory of the DFDR.

q. Reasonableness. An off-airplane review of recorded data to assess the overall health of the recording system parameter. The review requires technical judgment to assess a parameter's health functions off the airplane. Typically, the data is downloaded from the airplane and reviewed in a ground station tool away from the airplane, using graphical and tabular means. The review identifies gross parameter anomalies, such as static parameters, missing parameters, random movement in parameters, parameters not in agreement with related parameters in a given operational range or mode, etc. Judgment is required so that the reviewer does not confuse acceptable airplane operational differences with parameter recording anomalies (i.e., the reasonability check is for parameter health and not piloting technique).

r. 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.

(1) 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 input can be differentiated from the position of the flight control surface.

(2) In the example given, the installation instructions must tell 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.

s. Split Flight Control Parameter. This applies to flight control and flight control surface parameters when the flight control system design allows the flightcrew to disconnect the pilot's controls from the copilot's controls. This flight control system design is also known as breakaway capability.

(1) The DFDRS must record multiple flight control positions, as well as multiple flight control surface positions.

(2) 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 disconnection 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 only the left aileron, and the copilot capable of operating the right only.

(3) 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.

t. Sufficient Capacity. This 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, based on the aircraft date of manufacture (see Appendix 3). 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 paragraph 1-3o, Installed and Connected to the Recording System.)

u. When an Information Source is Installed. When this term appears in the parameter listing in the 14 CFR section or appendix, the parameter is mandatory only if the aircraft 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.

1-4. FOCUS. This AC provides information for the following:

- Type certification of a DFDRS installation.
- Continuous Airworthiness Maintenance Program (CAMP) information for compliance with the operating rules after DFDRS installation.

1-5. RELATED CFRs. Sections of 14 CFR parts 23, 25, 27, 29, 91, 121, 125, 129, and 135 prescribe design substantiation and operational approval requirements directly applicable to the DFDRS. Listed below are the specific 14 CFR sections that apply to this AC. See Appendix 3 to determine the applicable regulations for your aircraft.

- Section 23.1459, Flight recorders.
- Section 25.1459, Flight recorders.
- Section 27.1459, Flight recorders.
- Section 29.1459, Flight recorders.
- Section 23.1529, Instructions for continued airworthiness.
- Section 25.1529, Instructions for continued airworthiness.
- Section 27.1529, Instructions for continued airworthiness.
- Section 29.1529, Instructions for continued airworthiness.
- Section 91.609, Flight recorders and cockpit voice recorders.
- Section 91.1045, Additional equipment requirements.

- Section 121.343, Flight recorders.
- Section 121.344, Digital flight data recorders for transport category airplanes.
- Section 121.344a, Digital flight data recorders for 10-19 seat airplanes.
- Section 125.225, Flight recorders.
- Section 125.226, Digital flight data recorders.
- Section 129.20, Digital flight data recorders.
- Section 135.152, Flight recorders.

1-6. DFDRS PURPOSE. The purpose of a DFDRS is to collect accurate data to assist investigations of accidents and incidents The objective is met by complying with the current requirements in parts 91, 121, 125, 129, and 135.

1-7. OPERATING CERTIFICATE HOLDERS. A holder of an air operator certificate may not operate an aircraft on its operations specifications in air transportation unless that aircraft complies with the FDR requirements of the appropriate part (91, 121, 125, 129, or 135). See Appendix 3 to determine the applicable regulations for your aircraft.

CHAPTER 2. TYPE CERTIFICATION

2-1. PURPOSE. This chapter provides information for type certification of a DFDRS. The applicant must obtain FAA approval to install or to retrofit a DFDR and components. The applicant may apply for a TC, amended TC, STC, or other manner of approval. The applicant must demonstrate compliance with the applicable regulations included in the type certification basis for the aircraft. Appendix 4 lists typical certification requirements that are applicable depending upon the certification basis of the aircraft. The type certificate data sheet (TCDS) referenced in the TC normally identifies the applicable regulations. An applicant must demonstrate compliance with the appropriate certification requirements as instructed by the approving Aircraft Certification Office (ACO) or Flight Standards District Office (FSDO). (See Appendix 3.)

2-2. DFDRS SUBSTANTIATING DATA. The system description must include:

- The make and the model or part number of the DFDR, FDAU, or DFDAU (or equivalent function).
- A listing of each parameter recorded.
- Documentation which shows the correlation data for each parameter.
- Identification of all transducers or sensors installed specifically for the purpose of sensing required data. Include the manufacturer and part number of the sensor.
- Identification of sensors not dedicated exclusively to the DFDRS. Include the sensor source and the associated digital data bus source.
- Identification of pneumatic inputs directly connected to the DFDRS for pitot-static information.
- Identification of components of the DFDRS that meet Technical Standard Order (TSO) standards including the TSO number and any authorized deviations from the TSO requirements.
- Description of structural alterations associated with the installation.
- A wiring diagram and system schematic. Describe all dedicated wires. Identify all interfaces to other installed equipment and systems.
- Identification of parameters recorded from data buses. Must include source data bus system, word, and label information.

NOTE: Acceptable guidelines for documentation of DFDR data content and format are available in Appendix 1 and in the ARINC Flight Recorder Electronic Documentation (FRED) specification (ARINC Specification 647A). These data format guidelines provide NTSB accident investigators with the information necessary to decode the DFDR raw data

stream. The information can be contained in hardcopy document or electronic format. Specifically, the ARINC FRED standard provides the electronic format that supercedes a prior electronic format standard, the Flight Recorder Configuration Standard (FRCS), Document TP13140E. Although the FRCS standard is an acceptable electronic format for DFDR decoding information, the ARINC specification evolved from the FRCS format and includes information for various raw data stream formats. See Appendix 1.

2-3. INTENDED FUNCTION. The DFDRS records parametric data that represents (as closely as possible) the actual aircraft function. The applicant must provide a list of all parameters that the DFDRS will record and their specifications (range, accuracy, sampling rate, and resolution). The applicant must demonstrate, by test, that the DFDRS meets these specifications under both static and dynamic conditions. (See definition in chapter 1.) These tests are normally performed using simulated inputs to the DFDRS and by activating transducers and sensors installed as part of the DFDRS. When 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. See data stream format and correlation document as described in Appendix 1 and, if applicable, reverse DFDR data correlation procedures in Appendix 2.

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 TC, amended TC, or STC.

a. Identify Parameters. The applicant must identify any parameters that are filtered before they are recorded. For these parameters, the applicant must show that the actual sensed value of the parameter can be readily retrieved and unambiguously derived from the recorded value, and the derived value can be shown to be within the range, accuracy, sampling rate, and resolution as specified in the applicable operating rule appendix under both static and dynamic conditions. This must be shown by test.

(1) If it is necessary to use a process or procedure for deriving the actual recorded data, that process or procedure must be documented and provided to the aircraft operator to satisfy requirement part 121, §§ 121.344(j), 121.344a(d), 125.226(j), or 135.152(f)(2).

(2) The process or procedure must be performed during certification of the system.

(3) The applicant must 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 Aircraft Flight Manual (AFM) (supplement) to verify that AFM procedures have not been invalidated by the installation.

NOTE: The STC process does not provide for findings of compliance with operating rules such as § 121.344. An applicant for TC approval (TC, amended TC, or STC) may facilitate the operator's later demonstration of compliance to the operating rule by referencing the appropriate appendix and parameter numbers of part 91, 121, 125, 129, 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 part 25, § 25.1459(e) or equivalent.) The applicant must include the substantiation as part of the operational specifications or minimum equipment list. 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 part 11, § 11.63 for procedures to petition for an exemption.)

b. Demonstrate Performance. 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 correlation test of the DFDR data from the flight test. The purpose of this test 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. During the flight test, the applicant must demonstrate that the DFDRS is not susceptible to EMI or radio frequency interference (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. Establish Correlation. The applicant must establish the correlation between the raw data and the engineering unit for all mandatory parameters. (Reference § 121.344(j).) The correlation required in the type certification regulations (§ 25.1459(c), for example does not meet the requirement of § 121.344(j). The applicant should use the correlation coefficient to describe this relationship. For example, the correlation in § 25.1459(c) must be established between the flight recorder readings between airspeed, altitude, and heading and the corresponding readings of the first pilot's instruments. The correlation in § 121.344(j) is between the values recorded by the recorder and the corresponding values being measured.

2-4. 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. TSO-C124 (Flight Data Recorder Systems) Authorization. A DFDR or DFDAU that has been manufactured under TSO-C124 or later revision (as required by the applicable operating rule) is FAA-approved.

b. TSO-C121 (Underwater Locating Devices (Acoustic) (Self-Powered)) Authorization. A ULD that has been manufactured under TSO-C121 or later revision is FAA-approved.

c. Interleaving. Interleaving of certain parameters is permissible unless prohibited by the applicable operation regulation. However, interleaving is discouraged unless there is insufficient recorder capacity. Interleaving is defined as recording samples from multiple parts of a system and then combining them to meet the required sample rate for an individual parameter. An example of interleaving is recording the left aileron input twice per second and the right aileron twice per second, and then combining both of those recorded parameters for a total aileron sample rate of four times per second.

d. Source Selection. The source for the parameter should be selected to provide data that is as close (physically or electrically) to the original source as possible. Source selection is critical for providing accurate and timely data information for post accident and incident analysis. The data should be "handled" by as few components as possible before reaching the flight data acquisition function. When evaluating the suitability of cockpit displays as a DFDR data source, pay particular attention to nonflight critical information such as displayed flight control position, which is typically filtered to provide a smooth cockpit presentation. See Appendix 5 for additional guidance for filtered flight data.

e. 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's instrumentation and the other supplying the copilot's instrumentation, the pressure altitude and indicated or calibrated airspeed may be recorded from each air data computer. When there is no air data computer, or when independent altitude and airspeed indicators are installed, the pressure altitude and indicated or calibrated airspeed may be derived from either of the instrumentation systems or it may be derived from a separate pitot static system. When the data is derived, instrumentation systems must not be adversely affected.

f. Control Position and Forces (Nonfly-by-wire). Control positions and control forces must be measured at the control columns, control wheels, and rudder pedals when 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 bellcrank in the control linkage from the control. Should the applicant determine that installation of the sensor on this first control arm or bellcrank is impractical, the applicant should conduct an analysis to show that the hazard likelihood of mechanical interference that could invalidate the recorded position and force values is improbable ($1x10^{-6}$).

NOTE: Installation of force sensors are usually made in series in the control system. It is recommended that the TC holder review any STC force sensor implementation that revises or modifies the flight control system or that can affect the function of the autopilot or pilot controls.

g. Thrust Command and Thrust Target. Thrust command and thrust target are typically available on aircraft 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.

h. 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.

i. Multiple Control Surfaces (Flap Sections, Aileron/Spoiler Speed Brake Panels) and Combinations for Lateral Control. Unless there is insufficient recorder capacity on a retrofit aircraft and the designer can show that it is improbable that a surface would not deploy as intended:

(1) Ailerons on each wing must be monitored separately.

(2) Multiple aileron surfaces that are mounted on the same wing must be monitored separately.

(3) 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.

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

k. Hydraulic Pressure. Hydraulic pressure low, each system (parameter 33) and hydraulic pressure, each system (parameter 77) are both mandatory parameters. For example, although hydraulic pressure low is defined as a discrete, the comment in the range column of part 121, 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 low discrete or the actual analog hydraulic pressure may be recorded for all DFDRS installations except those on aircraft manufactured after August 19, 2002. For aircraft manufactured after August 19, 2002, both parameter 33 and parameter 77 are required.

l. Safety Analysis of Sensors Installed in Flight Control Systems. Some flight control surface and flight control input sensors consist of rotary synchros that are attached to 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 the likelihood of a catastrophic failure would occur $1x10^{-9}$ times per aircraft flight-hour. As a result of this assessment, the applicant may find it necessary to prescribe periodic inspection or replacement of the sensor(s) in the ICA.

NOTE: When installation of the sensors requires direct attachment to control cables, the attachment hardware must have the same metallurgical properties as the control cables. In addition, periodic inspection of the attachment hardware must be included in the maintenance program.

m. Sensor reliability. Be careful when selecting sensor types for particular applications. Specifically, certain sensors are less reliable in different applications than others. For instance, potentiometers have historically been unreliable on flight control surface applications where high vibration may be present. However, a similar sensor may be reliably used for other applications, such as pilot input controls.

NOTE: Potentiometers should be avoided in all cases for retrofit flight recording system design. Synchros, rotary variable differential transducers, and linear variable differential transducers are far more robust in the airplane environment.

2-5. COMBINATION COCKPIT VOICE RECORDER (CVR)/DFDR UNITS. Under longstanding FAA policy, an applicant may install a combination CVR and DFDR unit.

a. Airplane Requirements. Two separate recorders are required for airplanes. Therefore, a single 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 unit for either the required DFDR or CVR. The applicant may install two combination CVR/DFDR units in the airplane, one taking credit for each required system.

b. Rotorcraft Requirements. On rotorcraft, one combination CVR and DFDR unit may be installed to meet the requirement for a CVR and a DFDR. The combination CVR and DFDR unit must be installed such that no single electrical failure external to the recorder can disable both the cockpit voice recorder and the digital flight data recorder functions.

2-6. SOFTWARE. For those DFDRs having RTCA, Inc. document RTCA/DO-178B Level E or DO-178A Level 3 software installed, and those DFDRs for which no software approval exists, the person performing the installation or the applicant must:

- Obtain a statement from the equipment manufacturer that the source code has been archived;

- Obtain a statement from the equipment manufacturer that the executable object code can be regenerated from the archived source code;

- Obtain from the equipment manufacturer information necessary to calculate transfer functions; and

- 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 ICA, as appropriate.

2-7. COMPLEX ELECTRONIC HARDWARE. Reserved.

2-8. WEIGHT AND BALANCE. Installation or removal of equipment affects the aircraft weight and balance. A report must show the net change in weight and moment (or moment arm) and how the net change was determined. If the installation results in changes to the weight and balance procedures in the flight manual, submit a flight manual supplement to the ACO for approval. Adjust aircraft records to show such change.

2-9. ELECTRICAL LOADS ANALYSIS. Installation or removal of equipment affects the electrical load to the aircraft power distribution system. A report must show the net change in the electrical load on each affected bus and how the installer or applicant computed this net change. The installer or 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 distributed to other loads on that bus. Reference §§ 23, 25, 27, and 29.1351.

2-10. 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.

a. Connect to Power Buses. The applicant must connect the DFDR and the CVR to power buses 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.

b. Automatic Switching. 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.

c. External Power Sources. Separate aircraft external power sources are not required for installations of single combination CVR/DFDR unit. If there are more than one electrical power inputs available on the combination CVR/DFDR units, then connection with a separate and independent electrical power bus is recommended.

d. Direct Wiring. We recommend equipment manufacturers specify in the installation instructions that the DFDR be wired directly to the primary electrical power source.

2-11. CIRCUIT PROTECTIVE DEVICES. Circuit protective devices must be capable of handling anticipated loads for the DFDRS. Reference parts 23, 25, 27, and 29, § 1357 in each.

2-12. PREFLIGHT MONITORING MEANS. An aural or visual indicator is activated in the cockpit when any one of a combination of system status monitors and built-in test capabilities fails. For example, failure of the following functions will produce an indication, depending upon availability of built-in test capability:

- System electrical power,
- Data acquisition and processing equipment, and
- Recording medium and/or drive mechanism.

2-13. AIRCRAFT FLIGHT MANUAL APPLICABILITY. The installer or applicant must review the AFM and supplements to determine whether they are compatible with the DFDRS installation. The installer or applicant must provide an approved AFM supplement to eliminate any incompatibilities.

2-14. INSTRUCTIONS FOR CONTINUED AIRWORTHINESS (ICA). The installer or applicant must provide ICAs as part of the substantiating data. Under the requirements of §§ 23, 25, 27, or § 29.1529, and guidance found in FAA Order 8110.54, these instructions must include as a minimum and be provided to the operator or maintainer:

a. Data Stream. The data stream format and correlation data outlined in Appendix 1 or Appendix 2 if applicable.

b. Dedicated Sources. A list of dedicated sources as defined in chapter 1, subparagraph 1-3f. Include procedures for a ground check of these sources. Provide sufficient information, including source, label and word, to verify the range and accuracy of the recorded data as specified in the applicable operating rule.

c. Procedures and Intervals. Procedures and recommended check intervals to functionally check parameters with dedicated sources that are not typically activated and recorded during normal aircraft operation.

d. Checks. The instructions may reference procedures for checks furnished in the ICA for the parameter source systems. See Appendix 4 for typical reasonableness and quality check instructions.

e. Removal and Replacement. Provide removal and replacement instructions for DFDRS equipment and dedicated sensors. Include instructions for conducting a functional check of the equipment.

f. Battery Replacement. If the retrofit includes a change to the ULD, 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. Include instructions for how to access the ULD. The current edition of AC 21-10, Flight Recorder and Cockpit Voice Recorder Underwater Locating Devices, provides information for ULD installations.

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

g. Installation Design. The installer or 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 DFDRs 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 DFDRs, the installers may select either DFDR for installation. In this case, provide a list identifying the interchangeable items of equipment by make, model, and part number.

CHAPTER 3. CONTINUED AIRWORTHINESS REQUIREMENTS

3-1. PURPOSE. This chapter provides information for aircraft operators in the development of continued airworthiness requirements of a DFDRS. The basic requirements for continued airworthiness of a DFDRS should be provided as part of the data package submitted during TC, amended TC, or STC installation. This chapter outlines those basic requirements in case the original information was insufficient or not provided as part of the system certification.

3-2. CONTINUOUS AIRWORTHINESS MAINTENANCE PROGRAM (CAMP). A typical maintenance program should include all the checks necessary to ensure that the DFDRS operates as certified at specified intervals. Such intervals, or schedules, are delineated and described in AC 120-16, Air Carrier Maintenance Programs, current edition. The aircraft manufacturer or system designer/installer should provide the basic maintenance program recommendations. However, factors such as aircraft age, system design, and aircraft operation must be taken into account when developing the maintenance program. The following are typical parts found in a DFDRS maintenance program:

a. Operational Check. Check that there are no failures in the DFDRS. The flightcrew usually accomplishes this task. The task typically verifies that there are no DFDRS system fault indications. We recommend that the checks occur before the first flight each day.

b. Reasonableness Check. Provide for a download of the DFDR to accomplish a reasonableness check of the data. The maintenance program task will typically require removal of the data or the DFDR. This completes the aircraft portion of the maintenance task. The reasonableness check of the data is performed off-aircraft. The check of the data should be accomplished as soon as possible. The operator should have provisions for addressing and correcting any discrepancies found during the reasonableness check.

c. System Functional. Check. Perform a complete functional check of certain parameter inputs to the DFDRS to ensure the system is as certified. This functional check may be done in conjunction with a reasonableness check. Identify signals from parameter sources that cannot be verified during checks of other aircraft systems and equipment.

(1) This is particularly important for older analog systems that use dedicated sensors to provide input to the DFDRS. Sensor type and installation often determine the level of check that is necessary to ensure they remain within the certificated tolerances. For example, some installations use a string potentiometer installed on the aileron bellcrank to provide control wheel input position. If the output of this sensor is only used for the DFDRS, then this is a dedicated sensor. There are several things that could happen to this type of sensor that could make the data provided invalid. It could be adjusted or repositioned during maintenance to the aileron system. To ensure that the output from this sensor is still within the range and accuracy requirements of the installation, the output parameters must be verified. The following are some types of parameters that should be included in the system functional check:

(a) Dedicated sources.

(b) Analog discrete inputs or analog warning inputs that are not normally exercised during flight.

(2) The functional check need not include other parameters that verify the accuracy of the output during the source systems operational or functional check. This includes digital discrete input and digital warning input that are not normally exercised during flight.

3-3. ICA. The operator must maintain ICA as part of its manual. The aircraft manufacturer or the system installer typically provides the ICA but if they are not provided, the operator should develop them. The operator developed ICA must identify all requirements that would have been established at time of certification and any others subsequently identified by the FAA, e.g., those applicable under Airworthiness Directive (AD). These instructions must include as a minimum:

a. Data Stream. The data stream format and correlation data outlined in Appendix 1. If this is not available, it should be created from the document or software used to convert the raw data into EU. If the information needed cannot be derived from the download document/software, then the operator must perform the necessary test and analysis to reproduce the necessary documentation (see Appendix 2 if applicable).

b. Dedicated Sources. A list of dedicated sources is defined in chapter 1, subparagraph 1-3f. Include procedures for a ground check of these sources. Provide sufficient information, including source, label and word, to verify the range and accuracy of the recorded data as specified in the applicable operating rule.

c. Removal and Replacement. Include removal and replacement instructions for DFDRS equipment and dedicated sensors. Also include instructions for conducting a functional check of the equipment and verification of the parameter range and accuracy.

d. Software. If chapter 2, paragraph 2-6 applies, include procedures for loading software during DFDRS installation or during DFDRS maintenance. (See FAA Order 8110.49, Software Approval Guidelines.)

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

1. DFDR. The DFDR 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 EU or to discrete states for an accident investigator to use the data. This appendix provides the specific information that operators must provide to the NTSB investigators for them to decode and convert the raw data stream recorded by the DFDR. This data format information can be contained within an electronic file or in hardcopy document format.

2. GUIDELINES FOR DOCUMENTATION. Information regarding acceptable guidelines for documentation of DFDR data content and format are also available in the FRED document, ARINC Specification 647A. The ARINC FRED specification provides a standard format for electronic documentation of DFDR data. This standard format supersedes an older electronic format, the Flight Recorder Configuration Standard, Document TP13140E. Although the FRCS documentation format is acceptable, because FRED supersedes TP13140E, the preferred electronic format is the ARINC FRED format. The FRED specification, ARINC 647A, can be obtained by contacting:

ARINC Inc.
Document Section
2551 Riva Road
Annapolis, MD 21401-7465
Telephone: (410) 266-4117
Fax: (410) 266-2047
E-mail: standards@arinc.com

3. DEFINITIONS. The following definitions apply to terminology often used in the DFDR correlation documentation. These definitions are derived from ARINC Characteristic 717-10, Flight Data Acquisition and Recording System, dated April 1, 1998. An operator using another data stream format must provide definitions unique to its format in the correlation documentation.

a. 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. To aid in the standardization of parameter identification, ARINC Specification 647A appendix C contains a recommended lexicon.

c. Mnemonic Code. An abbreviation of the parameter name. It is intended to be used in formats where the parameter name is too large. The mnemonic code must be unique and used to identify the parameter as described in the applicable appendix (part 121 appendix B or M, part 125 appendix E, or part 135 appendices B through 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, an installer or an operator may assign a mnemonic code to an 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.

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 or applicant'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 EU. 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 "NA" for discrete parameters. Range of a parameter is defined by either:

(1) The full recordable range of the parameter on the flight recorder, or

(2) The parameter's operational range. The operational range is typically a subset of the recordable range. The inclusion of operational range is useful in analysis of the recorded data.

NOTE: The inclusion of a parameter's recorded range does not imply that the parameter is recorded linearly on the flight recorder.

f. Signal Source. The aircraft subsystem, or the dedicated transducer or signal conditioner, used 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 Number. The location of a 12-bit word within the subframe. Word numbering starts at 1 (the first word in the subframe).

4. DATA STREAM FORMAT.

a. 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. Data stream format and encoded data format characteristics must be described and accurate to the specification provided by the manufacturer. The output of the data stream format should provide clear header and parameter information from the DFDR. Most DFDR data are encoded using the ARINC Characteristic 573 or ARINC Characteristic 717. Although these ARINC data bus encoding systems do not specify the data format, they provide the framework within which the data is formatted, in a fixed-frame format.

b. Frames and Subframes. Specifically, they generate 12-bit words with a word rate that may vary, i.e., 32, 64, 128, 256, 512, or 1024 (words/second). The data is organized into frames that are repeated every 4 seconds. Each frame consists of 4 subframes. Each subframe occupies 1 second in the data stream, however, not all data streams are ARINC compliant and a subframe may occupy more or less than 1 second. 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.

c. Header Information. For DFDRs that conform to ARINC characteristics, the following information should 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.) The header file must include:

(1) Aircraft make and model.

(2) Aircraft serial number.

(3) DFDR make and model/part number.

(4) Number of subframes per frame, for a fixed-frame. Or a description of each of the frame formats in a multiple-frame format data stream.

d. Record Information.

(1) For a fixed-frame format:

(a) Bits in the DFDR word.

(b) Number of DFDR words in a subframe.

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

(2) For a multiple-frame format:

(a) List of parameters in the frame, in order.

(b) The number of bits used to store each parameter.

e. Parameter Information. The identification for each parameter should include:

(1) Parameter name—must be unique from all other parameters recorded.

(2) Mnemonic code—a common abbreviation for the parameter, which must be unique from the mnemonic codes of all other parameters recorded.

f. Parameter Location. Both component(s) and timing information should be provided for each parameter sample. Usually there is only one component. For samples having more than one component the components should be ordered from least significant to most significant in the data stream. Each sample location for a parameter should 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:

(a) Cycle counter name.

(b) Cycle numbers.

5. LEXICON OF MNEMONIC CODES. If mnemonic codes are used, a lexicon of these codes must be provided.

6. EU CONVERSION. EU 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 EU conversion results in an interim parameter (e.g., alternating current voltage ratio No. 1, frequency, direct current 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 EU. 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 ARINC Specification 647A appendices E and F. Instructions must be provided to enable the accident investigator to convert the recorded data to EU An example of acceptable conversion equations are as follows:

a. Linear Equation.

$$EU = A_0 + A_1 \times CNTS_{10}$$

where: EU is the value in engineering units

A_0 is the number of EU when the $CNTS_{10} = 0$

A_1 is the slope of the line in EU per decimal count

$CNTS_{10}$ is the number of binary or binary coded decimal (BCD) counts converted to decimal counts

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 (EU) $\leq$ 500 feet	For Altitude (EU) $>$ 500 feet
$A_0 = (-0.002)$	$A_0 = (-0.29673)$
$A_1 = (0.0200231)$	$A_1 = (0.013351)$

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

c. Polynomial Equation.

$$EU = A_0 + A_1 \times CNTS_{10} + A_2 \times CNTS_{10^2} + \ldots A_x \times CNTS_{10^X}$$

where, EU is the value in engineering units
$CNTS_{10}$ is the number of binary or BCD counts converted to decimal counts
A_0 is the number of EU when the $CNTS_{10} = 0$
$A_1, A_2, \ldots A_X$ 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. This documentation may contain sufficient information to allow a tool programmer the ability to develop a conversion that uses his tool efficiently.

7. EU DATA CORRELATION. When certifying new parameter implementations, an acceptable procedure to correlate the recorded data to the data derived from the conversion equation follows:

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

(2) Record the data in the Raw Data (EU) column of Table 1-2.

(3) Record the decimal counts from the DFDR record in the $CNTS_{10}$ column of Table 1-2.

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 binary, octal, or hexadecimal format with octal being the most common. Convert the counts to decimals using instructions provided by the equipment manufacturer.

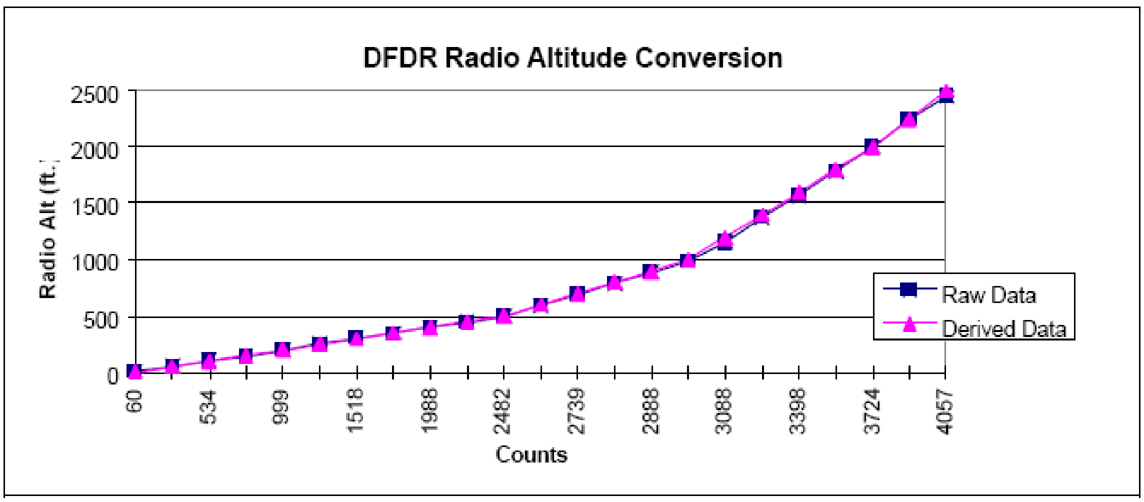
(4) Repeat steps (1) through (3) above until a sufficient number of data points have been collected for correlation.

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. For polynomial equation parameters, the more data points taken for correlation will produce a higher quality conversion formula. Also, the recorded data points must include one at each end of the range and sufficient intermediate points to produce an accurate conversion formula. For piece-wise linear equations, a minimum of three data points must be recorded for each linear segment of the equation.

(5) Derive the EU value for each recorded $CNTS_{10}$ value using the conversion equation or method provided. Record the derived value for each data point. When necessary intermediate conversion methods may be used to improve conversion accuracy of the parameter.

(6) 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.

FIGURE 1-1. AN EXAMPLE PLOT OF THE RADIO ALTIMETER IN FEET VERSUS DECIMAL COUNTS



8. 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 1-1. The word slot, subframe, and bit logic for the specific discrete codes must be identified in the documentation.

TABLE 1-1. 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”			0	1	0	0	0

9. VALIDATION OF EU CORRELATION.

a. Correlation Coefficient. Calculate the correlation coefficient between the raw data and the derived data. Table 1-2 may be used to aid this calculation. The following method may be used to calculate the correlation coefficient for a parameter that is linearly converted.

$$1 = \frac{N \times \Sigma(x \times y) - \Sigma x \times \Sigma y}{\left(\left[N \times \Sigma x^2 - (\Sigma x)^2\right] \times \left[N \times \Sigma y^2 - (\Sigma y)^2\right]\right)^{1/2}}$$

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

TABLE 1-2. CORRELATION TABLE DECIMAL COUNTS TO EU

<table>
<tr><td colspan="2">Parameter No.</td><td colspan="2">Parameter</td></tr>
<tr><td>Conversion Method</td><td>☐ Linear</td><td>☐ Polynomial</td><td>☐ Unique</td></tr>
<tr><td colspan="2">A_0</td><td colspan="2">Unique Equation Reference:</td></tr>
<tr><td colspan="2">A_1</td><td colspan="2"></td></tr>
<tr><td colspan="2">A_2</td><td colspan="2"></td></tr>
<tr><td colspan="2">A_3</td><td colspan="2"></td></tr>
<tr><td colspan="2">A_4</td><td colspan="2"></td></tr>
<tr><td colspan="2">A_5</td><td colspan="2"></td></tr>
<tr><td>Data Point No.</td><td>Raw Data (EU)</td><td>$CNTS_{10}$</td><td>Derived Value (EU)</td></tr>
<tr><td>1</td><td></td><td></td><td></td></tr>
<tr><td>2</td><td></td><td></td><td></td></tr>
<tr><td>3</td><td></td><td></td><td></td></tr>
<tr><td>4</td><td></td><td></td><td></td></tr>
<tr><td>5</td><td></td><td></td><td></td></tr>
<tr><td>6</td><td></td><td></td><td></td></tr>
<tr><td>7</td><td></td><td></td><td></td></tr>
<tr><td>8</td><td></td><td></td><td></td></tr>
<tr><td>9</td><td></td><td></td><td></td></tr>
<tr><td>10</td><td></td><td></td><td></td></tr>
</table>

b. Calculate the Correlation Coefficient. Table 1-3 demonstrates the steps in solving for the correlation coefficient.

TABLE 1-3. CORRELATION COEFFICIENT CALCULATION

Parameter No. ___			**Parameter Name ______________________________**		
			Mnemonic Code _____________		
			Parameter Word Location ___________________		
			Subframe _______________		
			Superframe Cycle ___________________		
			Assigned Bits (1 through 12) __________________		
			Range (EU) ______________________		
			Sign Convention _______________________________		
			Correlation Coefficient _________		
Data Pt No.	**x Raw Data (EU)**	**y Derived Value (EU)**	x^2	y^2	$x \times y$
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
N=	$\Sigma x =$	$\Sigma y =$	$\Sigma x^2 =$	$\Sigma y^2 =$	$\Sigma(x \times y) =$

(a) $N \times \Sigma(x \times y) =$ _____

(b) $\Sigma x \times \Sigma y =$ _______

(c) Subtract (b) from (a)

$$N \times \Sigma(x \times y) - \Sigma x \times \Sigma y = \_\_\_\_\_\_$$

(d) $N \times \Sigma x^2 =$ _____

(e) Square the sum of x (Σx) and subtract this square from (d)

$$\left[N \times \Sigma x^2 - (\Sigma x)^2\right] = \_\_\_\_\_$$

(f) $N \times \Sigma y^2 =$ _____________

(g) Square the sum of y (Σy) and subtract this square from (f)

$$\left[N \times \Sigma y \quad - (\Sigma y)^2\right] = \_\_\_\_\_\_\_\_\_\_\_\_\_$$

(h) Multiply (e) and (g)

$$\left[N \times \Sigma x^2 - (\Sigma x)^2\right] \times \left[N \times \Sigma y^2 - (\Sigma y)^2\right] = \_\_\_\_\_\_\_\_\_\_$$

(i) Take the square root of (h)

$$\sqrt{\left[N \times \Sigma x^2 - (\Sigma x)^2\right] \times \left[N \times \Sigma y^2 - (\Sigma y)^2\right]} = \_\_\_\_\_\_\_\_$$

(j) Divide (c) by (i)

$$1 = \frac{N \times \Sigma(x \times y) - \Sigma x \times \Sigma y}{\sqrt{\left[N \times \Sigma x^2 - (\Sigma x)^2\right] \times \left[N \times \Sigma y^2 - (\Sigma y)^2\right]}} = \_\_\_\_\_$$

NOTE: The correlation coefficient (r) must not be less than 0.99.

c. Non-Linear Conversions. For non-linear parameter conversions, the following method, or method in **(d)** below, may be used to calculate the correlation coefficient. The Sum of Least Squares is used to determine the fit of data to a function in non-linear regression. The objective in the curve fit is to minimize the sum of the squared errors.

Coefficient of Determination or the Sum of Least Squares method is performed by using the following equation:

$$RSS = \sum_{i=1}^{n} \left(y_i - \int (x_i)\right)^2$$

where x_i and y_i are known values and $f(x_i)$ is the calculated y value from the curve fit function.

d. Coefficient of Determination, R^2

$$R^2 = 1 - \frac{SS_E}{SS_T}$$

$$SS_T = \sum_i (y_i - \bar{y})^2, SS_E = \sum_i (y_i - \hat{y}_i)^2$$

Where SS_E is the RSS in paragraph (c) above.
SS_T is the Total Sum of Squares. The range of R^2 is from 0 to 1.
0 = no correlation and the data is correlated when $R^2 = 1$.

APPENDIX 2. REVERSE DFDR DATA CORRELATION PROCEDURES

1. PURPOSE.

a. Reverse Engineer a DFDR Data Correlation Document. This appendix characterizes reverse DFDR data correlation procedures acceptable to the FAA. We outline steps you can take to reverse engineer a DFDR data correlation document. Reverse DFDR data correlation procedures can be useful if a baseline data correlation document does not exist for a particular aircraft installation. Instead of recreating a data correlation document, an aircraft operator may follow these procedures. This appendix may be beneficial in reducing time and cost to develop or obtain a data correlation document.

b. Ensuring Performance. The following procedure gives information to DFDR test engineers and operators who conduct maintenance checks and other DFDR airworthiness certification activities. These procedures may be used to ensure the DFDRS, as installed, is performing its intended function. Allowable tolerances in the CFRs are greater than those tolerances derived in this appendix. These procedures are an acceptable means to show compliance with DFDR operating requirements in parts 91, 121, 125, 129, and 135.

2. DEFINITIONS. Several key terms used in this appendix need to be identified and defined to establish an unambiguous understanding of the language. These terms defined herein are for purposes of this appendix material and are applicable to the following reverse DFDR data correlation procedures.

a. Conventional Form of Digital Outputs. When extracting the recorded DFDR data, the conventional form of digital outputs is the numerical format implementation of how the digital data is displayed. For example, data can be represented in the form of octal numbers, hexadecimals, etc. This digital output is commonly converted into decimal units, and further converted into useful engineering data.

b. Conversion Document. Information on how to represent a system's EU in the form of decimal units or vice versa. Depending on the ARINC Specification 429 word structure, the conversion method may vary from classic analog look-up tables to digital binary representation high-order polynomial equations. A conversion document can be referred to as a DFDR's "data map."

c. DFDR Field Test. A validation check performed onboard an aircraft to compare actual data to recorded data. For the purposes of this definition, keep in mind that the data correlation document is unproducible. Other required validation steps must be performed and are described later in this appendix. The following steps are typical DFDR field test procedures.

(1) Test each required parameter over a precise and realistic functional range.

(2) Record the DFDR data output in any conventional form (i.e., hexadecimal, octal, binary, etc.).

(3) Using common mathematical techniques, convert the DFDR data output into decimal units, depending on the conventional form of digital output.

(4) Plot each data output parameter in EU versus decimal units.

d. Input. A piece of information required to begin a procedure. During a procedure, inputs are intended to be used or manipulated to achieve a desired output.

e. Interface Control Documents (ICD).

(1) Data mapping documents that explain the wiring configuration of internal and external DFDRS component interfaces. All source system signals are sent to the recorder. These signals are traced internally to the final recording format. Every make, model, and series of aircraft has a related series of ICDs for recorded data. For example, a DFDAU ICD describes and defines the electrical interface characteristics and requirements of the line replaceable units (LRU) to the DFDAU.

(2) Data mapping documents contain expected signal input and output information for each recorded parameter type, which can be any of the following ARINC Specification 429 signal formats:

(a) Analog data bit,

(b) Discrete data bit,

(c) Coded discretes,

(d) Binary representation,

(e) Digital BCD, or

(f) Digital encoded parameter.

(3) Other information includes the parameter type, word, subframe, location of the bit(s) in the word (word structure), and total number of bits used in the word. This document may be used to obtain inputs for Procedure A (see paragraph 3).

f. Number of Bits. The number representing how much space is required to store the data in a digital word. This number can range from 1 to 12 per ARINC Characteristic 717. If a parameter resolution is not identified, then this number is critical to the useful effectiveness of this appendix. To determine the resolution by assessing the number of bits, see paragraph 2j.

g. Output. A piece of information obtained after the completion of a procedure. The outputs produced may be used as inputs for another procedure.

h. Parameter Detail Document (PDD). Digital parameter specific information. Like a DFDR ICD, this document may be used to obtain inputs for Procedure A.

i. Range. A set of functional and numerical values bounded by a maximum and a minimum. As defined by the input data to Procedure A, the functional range may not truly reflect the exact range of a particular aircraft operational or performance parameter. This appendix refers to range as the "change in range", or by the symbol ΔR. For example, if given a range $[R_1, R_2]$, then the total change in range is:

$$\Delta R = R_2 - R_1$$

j. Resolution. An EU representation of the least significant bit (LSB) in the word structure. This LSB is important when calculating the value of a digital binary type parameter. If the parameter resolution is not identified in the input information, then the resolution must be determined. Given the number of bits and the range in EU, a linear resolution can be calculated by using the following equation:

Where, ΔR is the total change in range, derived in paragraph 2i, measured in EU, and NB is number of bits, the parameter resolution is denoted by:

$$res = \frac{\Delta R}{\left(2^{NB}\right)}$$

NOTE: It is important to document an appropriate number of decimal places (or express the resolution as a fraction) to avoid the introduction and propagation of error.

3. REVERSE DFDR DATA CORRELATION PROCEDURE A. This paragraph describes the first procedure that DFDR test engineers may follow in conjunction with Procedures B and C to develop an acceptable baseline correlation document, when no document exists.

a. Requirements. This paragraph identifies the required data items needed to begin reverse engineering the DFDR data correlation document.

(1) Procedure A requires a search for and an identification of parameter specific information. ICDs, PDDs, and conversion documents are resources that contain information to perform Procedure A. The required minimum inputs to conduct Procedure A are conversion algorithms (decimal units to EU), ranges (EU), and either resolutions or number of bits in the digital word.

(2) The following example illustrates how to find ΔR when given a parameter's range. If the range of the roll attitude parameter is –180˚ to +180˚, then the total change in range, ΔR, is:

$$\Delta R = +180° - \left(-180°\right) = 360°$$

The parameter resolution in EU may not be available from the resource documents. If the parameter resolution is not identified in the input information, then the resolution must be determined from the number of bits. If roll attitude is the parameter of interest, then the following is an example of how to solve for a linear resolution. Given the number of bits is 12 and the change in range is given in the previous example, the linear resolution can be solved by using the following equation:

$$res = \frac{\Delta R}{\left(2^{NB}\right)} = \frac{360}{4096}$$
$$res = 0.0879$$

(3) A conversion document contains the algorithms, tables, or codes to convert applicable parameters from EU to decimal units. This information is critical in completion of reverse data correlation. Depending upon the ARINC Specification 429 data word structure of a specific parameter, an algorithm or conversion equation, a look-up table, or a conversion code is required to perform the conversion. An example of a binary formatted data conversion algorithm is below. In this example roll angle is measured in degrees, such that:

$$\text{Decimal unit} = 0.0000000000001515 \times \varphi^5 + 0.0000000000003167 \times \varphi^4 - 0.0000001424806891 \times \varphi^3 + 0.0000003524948261 \times \varphi^2 + 0.1155043360208260 \times \varphi + 0.0046571693139939$$

where φ denotes the roll angle in E. U.

(4) Now that the required inputs for Procedure A are gathered, paragraph 3b lays out the foundation to derive baseline correlation data.

b. Process. This paragraph outlines the steps to create the baseline of manufacturer system-specific data.

(1) A baseline must be established that translates a 1 to 1 correlation between decimal units and EU for the full range of every parameter. For each parameter, use the conversion algorithm or other method to calculate the full range in decimal units.

(2) Begin plotting the lowest value in the full range against the respected decimal unit. Then, increment the resolution to obtain decimal unit values for all 2^{NB} range values. All 2^{NB} values are plotted with an uncertainty of half the resolution, $\pm\frac{res}{2}$.

c. Data Application/Desired Output. This paragraph identifies the required data to be produced by following Procedure A.

(1) In Procedure A, DFDR parameter information was gathered to convert the full range from EU to decimal units. The conversion algorithm or other method was utilized to create a baseline of DFDR system data. The baseline conversion data must be stored or displayed in some documented fashion.

(2) If applicable, the parameter's resolution must be converted from EU to decimal units. In the case of a parameter with a non-linear resolution, an EU to decimal conversion must be considered from decimal count to decimal count. Section 5 discusses the significance and applicability of the parameter's resolution to this appendix.

(3) A baseline plot for an identified parameter.

(a) One example of displaying the baseline data is by plotting individual data points. One implementation would be to plot decimal units as a function of EU, with increments of the resolution determined in paragraph 3c. The following linear baseline plot, Figure 2-1, is a continuation of the roll attitude example from previous paragraphs. Figure 2-2 shows an example of a nonlinear baseline plot.

(b) If a baseline plot cannot be established with reasonable accuracy, then ground station tools may be required to perform an accurate baseline plot of intermediate converted values. For example, some DFDRS implementations process synchro signals which increases both the complexity and accuracy of a decimal unit to EU conversion.

FIGURE 2-1. EXAMPLE LINEAR BASELINE PLOT OF EU TO DECIMAL UNITS

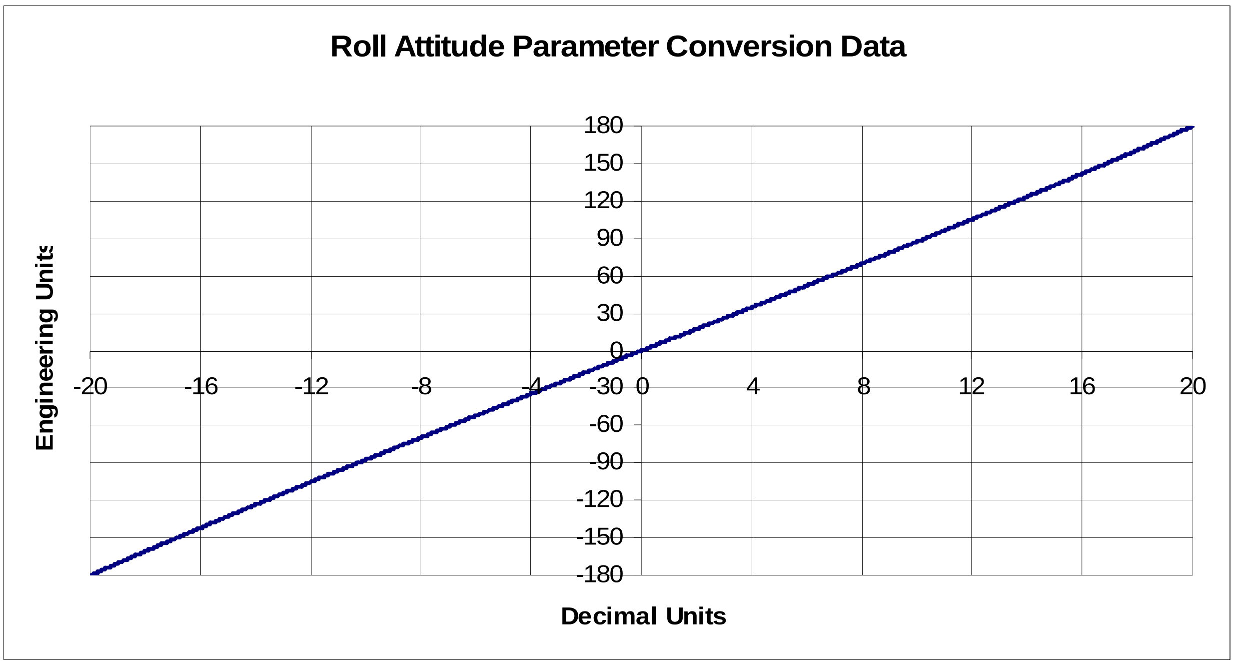
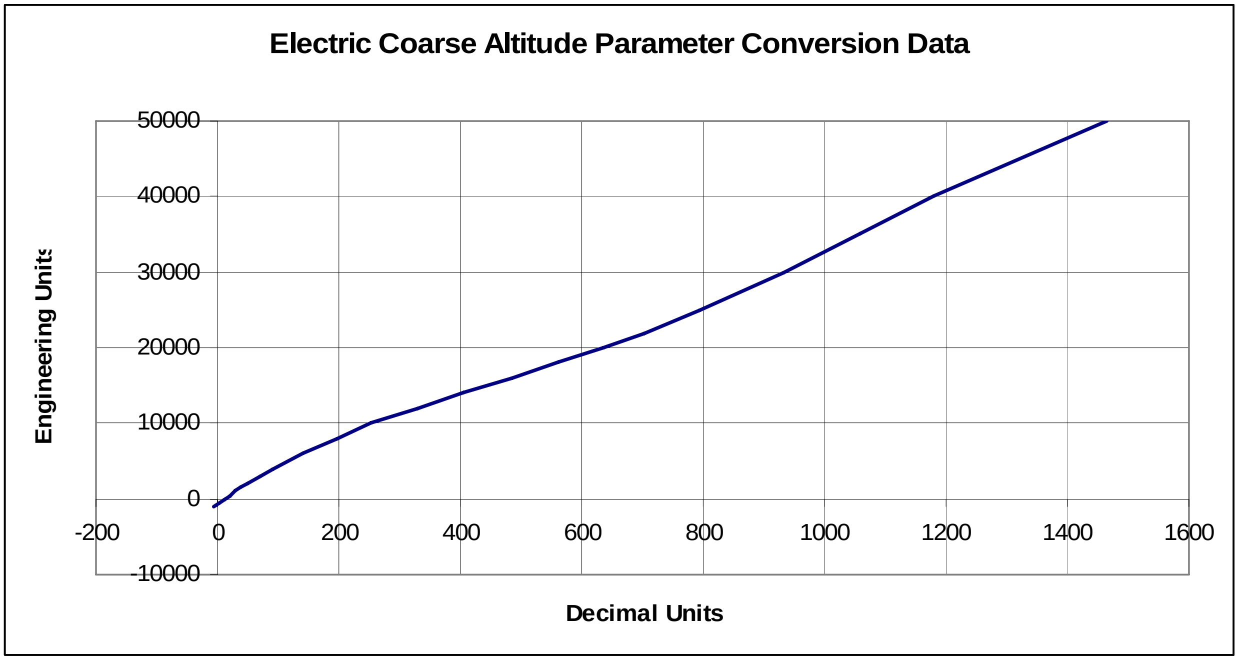


FIGURE 2-2. EXAMPLE NON-LINEAR BASELINE PLOT OF EU TO DECIMAL UNITS



(4) Once data storage or display is complete, this information is used in paragraph 5 as a baseline to determine compliance with the CFR.

4. REVERSE DFDR DATA CORRELATION PROCEDURE B. This paragraph identifies the data items needed to complete the required aircraft test of DFDR data reverse correlation. Accomplishing this procedure depends on the availability of the aircraft to be tested.

a. Requirements. Procedure B requires the data ranges for each parameter, a DFDRS-equipped aircraft, and all equipment necessary to test the onboard DFDRS. The decimal unit to EU conversion algorithm or method is required. The operator or test engineer must have a predetermined list of data points to test for each parameter through the static and full dynamic ranges. This list of data points must be in EU and correlate to one of the 2^{NB} data points obtained in Procedure A. It is also useful to have a tool capable of converting conventional forms of digital outputs into decimal units.

NOTE: There are cases where certain types of parameters cannot be tested in the airplane environment. These parameters can only be stimulated in a lab environment and applied to the airplane through analysis. For example, a computer failure can be simulated in the lab environment and the software paths of the acquisition unit can be confirmed. This testing can be applied to the airplane where it is rare that one can force working equipment to fail for test purposes. Credit should be given that source systems that provide data to the acquisition unit had these functions tested during their certification.

b. Process. The test engineer evaluates the DFDRS recorded data based on the data ranges for each parameter.

(1) The test engineer must use the predetermined list of data points to be recorded as identified in paragraph 3.

(2) By controlling the aircraft input, the conventional form of the digital output is to be recorded.

(3) The conventional form of the digital output must be converted into decimal units. A capable tool (i.e., calculator, computer application, etc.) makes this conversion easier.

c. Data Application/Desired Output. This paragraph identifies the required data to be produced by following Procedure B.

(1) The parameter's static and full dynamic ranges and recorded outputs should be stored or displayed. Use a method similar or comparable to that used in Procedure A (i.e., plot EU as a function of decimal units).

(2) Once data storage or display is complete, this information is used in paragraph 5 to compare against the baseline to determine compliance with the CFR.

5. REVERSE DFDR DATA CORRELATION PROCEDURE C. This paragraph outlines the process to determine compliance with the CFR. It defines a comparative assessment between actual aircraft measured data and manufacturer system-specific data. If regulatory compliance is not determined, then the operator must choose to either repair, recorrelate, or replace the noncompliant system. Procedures A and B must be accomplished before completing Procedure C.

a. Requirements. This paragraph identifies the required data items needed to accomplish DFDR data reverse correlation. The recorded conversion data from Procedures A and B are required to begin Procedure C. If applicable, the parameter's resolution from Procedure A is also required and is critical in determining an acceptable parameter correlation.

(1) Procedure A contributes manufacturer-specific system conversion and parameter information. For each parameter, a baseline with digital tolerances was established. If applicable, an EU to decimal unit representation of expected DFDR system operational performance was created. In the following discussion, data obtained from Procedure A will be referred to as "expected" data.

(2) Procedure B contributes aircraft-specific DFDR data from testing the static and full dynamic range of each parameter. The number of data points recorded is discretionary, greater numbers of data points increase the probability of the parameter being in compliance. The actual data stored in an aircraft's DFDR needs to be verified through a comparative assessment with the data from Procedure A. In the following discussion, data obtained from Procedure B will be referred to as "measured" data.

b. Process. This paragraph outlines the steps to complete the analysis and to determine compliance.

(1) Once the data from Procedure A and B are present, a comparative assessment is required. This analysis relates an aircraft-specific DFDR operational performance to the expected DFDR operational performance as documented by the system manufacturer.

NOTE: We recommend use of a graphing program with the capability to calculate "R" numbers. It is useful to plot the measured data points on the expected baseline graph. An "R" number should be produced to read 0.99 or greater in order to achieve regulatory compliance.

(2) First, select the EU values for which there are both expected and measured data. Then, obtain the decimal unit values for each data pair. Use the following statement to compare the decimal unit values for the expected and measured data.

(3) If the measured data, denoted as X_m, is within the expected data plus or minus half the resolution, denoted as $X_e \pm \frac{res}{2}$, then the parameter data value is known with 100 percent certainty to be in compliance. This statement is represented mathematically by,

$$X_e - \frac{res}{2} \le X_m \le X_e + \frac{res}{2}$$

The above comparative analysis must be made for each parameter's operational range.

c. Data Application/Desired Output. This paragraph provides recommendations and information based on the conclusions from the analysis in paragraph 5b. The analysis in paragraph 5b concludes that:

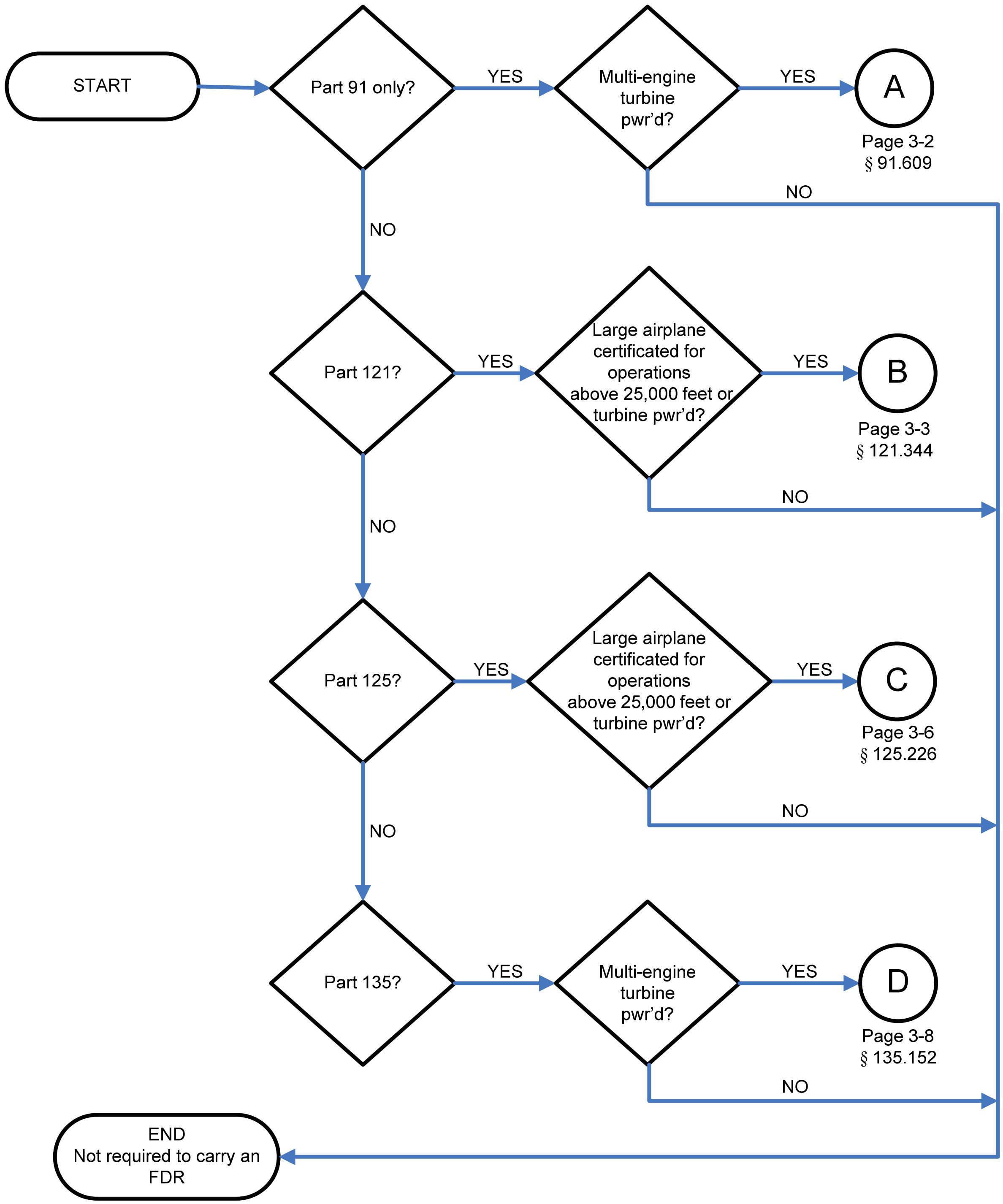
(1) The design is in compliance with 14 CFR,

(2) The system relating to the applicable parameter sensor needs to be recalibrated, or

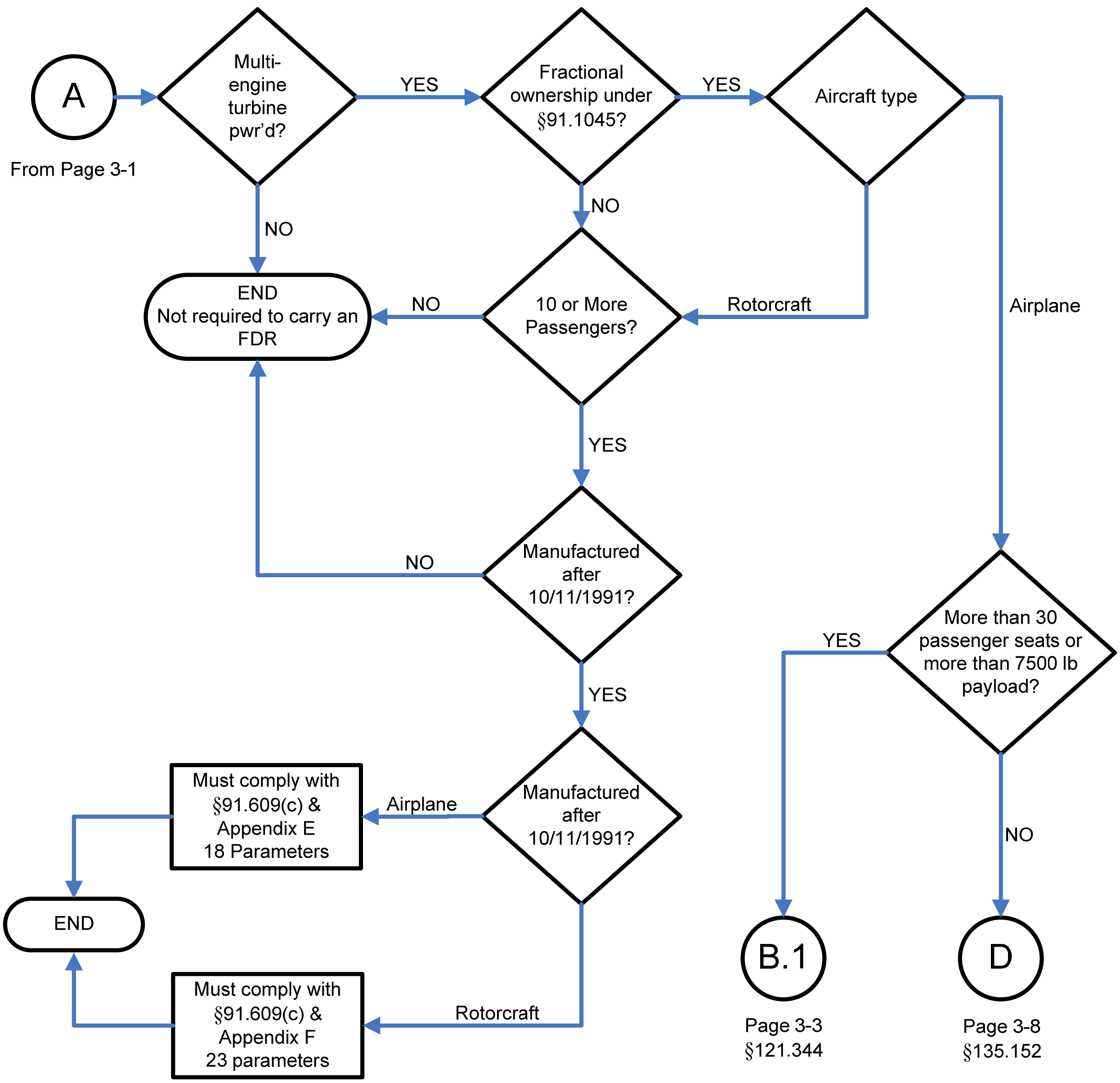
(3) The parameter must be recorrelated.

d. Ensure Compliance. The final step is to ensure that the parameters with measured data not within the expected data limits are in compliance. To reach conclusion (2) above, the data must be analyzed and a consistent discrepancy must be identified between the measured and expected data values. While the applicable system is in a neutral state, adjust to within the limits. Conclusion (3) above is a result of random inaccurate trends identified in the comparison analysis. The applicable system needs to be repaired, or replaced.

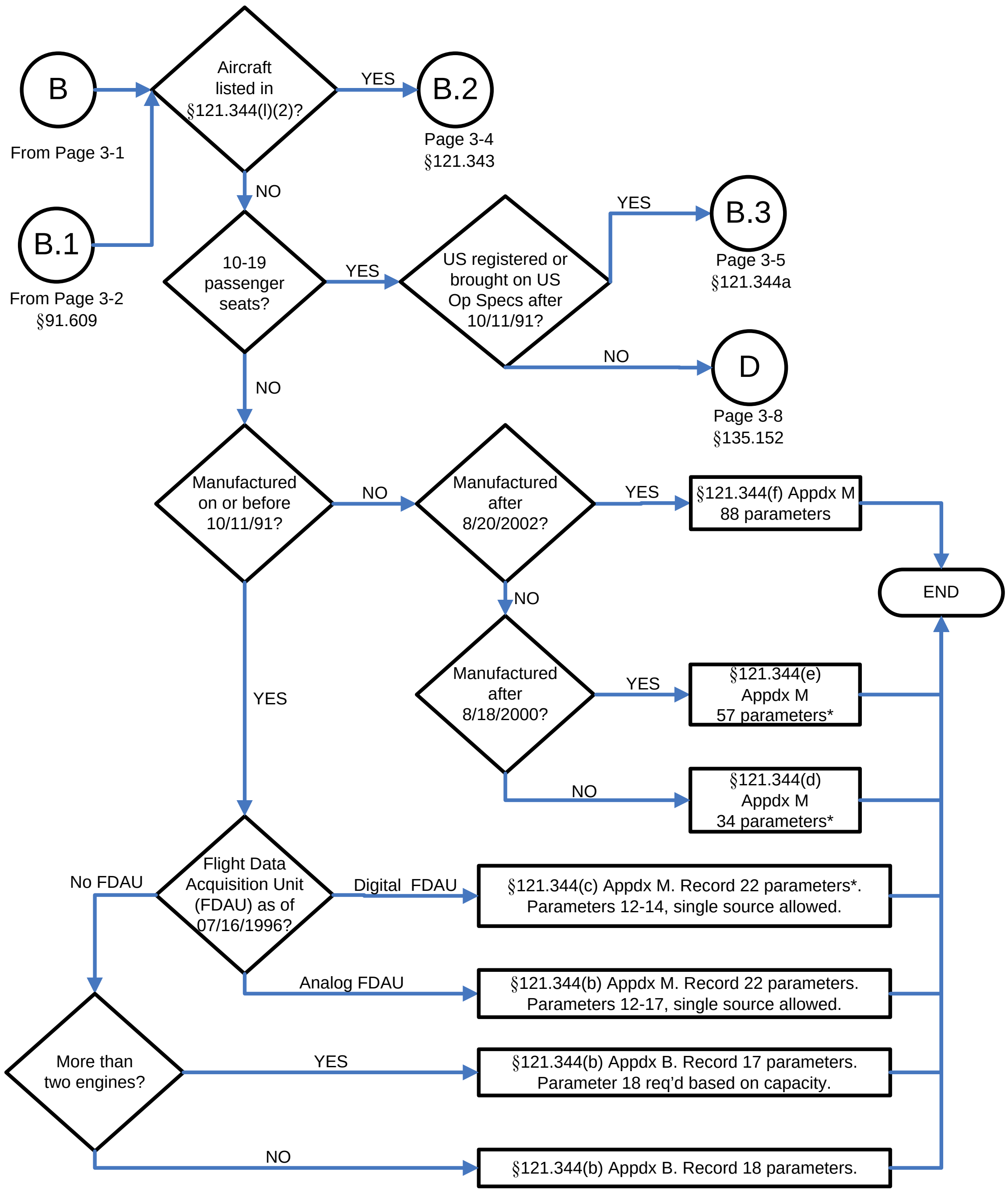
APPENDIX 3. DIGITAL FLIGHT DATA RECORDER PARAMETER REQUIREMENTS FLOWCHART



Part 91 Flight Recorder Parameter Requirements,
§91.609

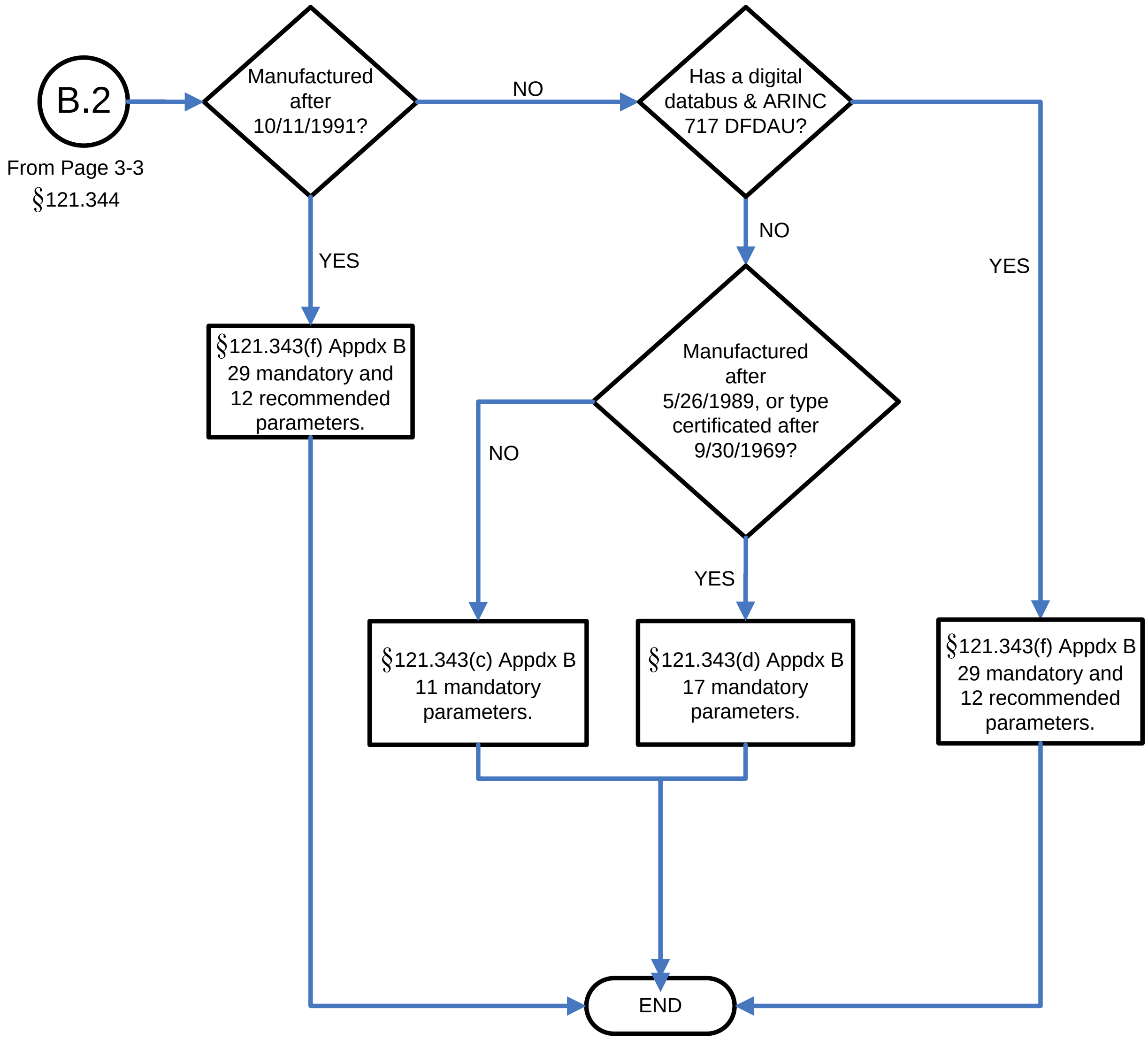


Part 121 Flight Recorder Parameter Requirements, §121.344

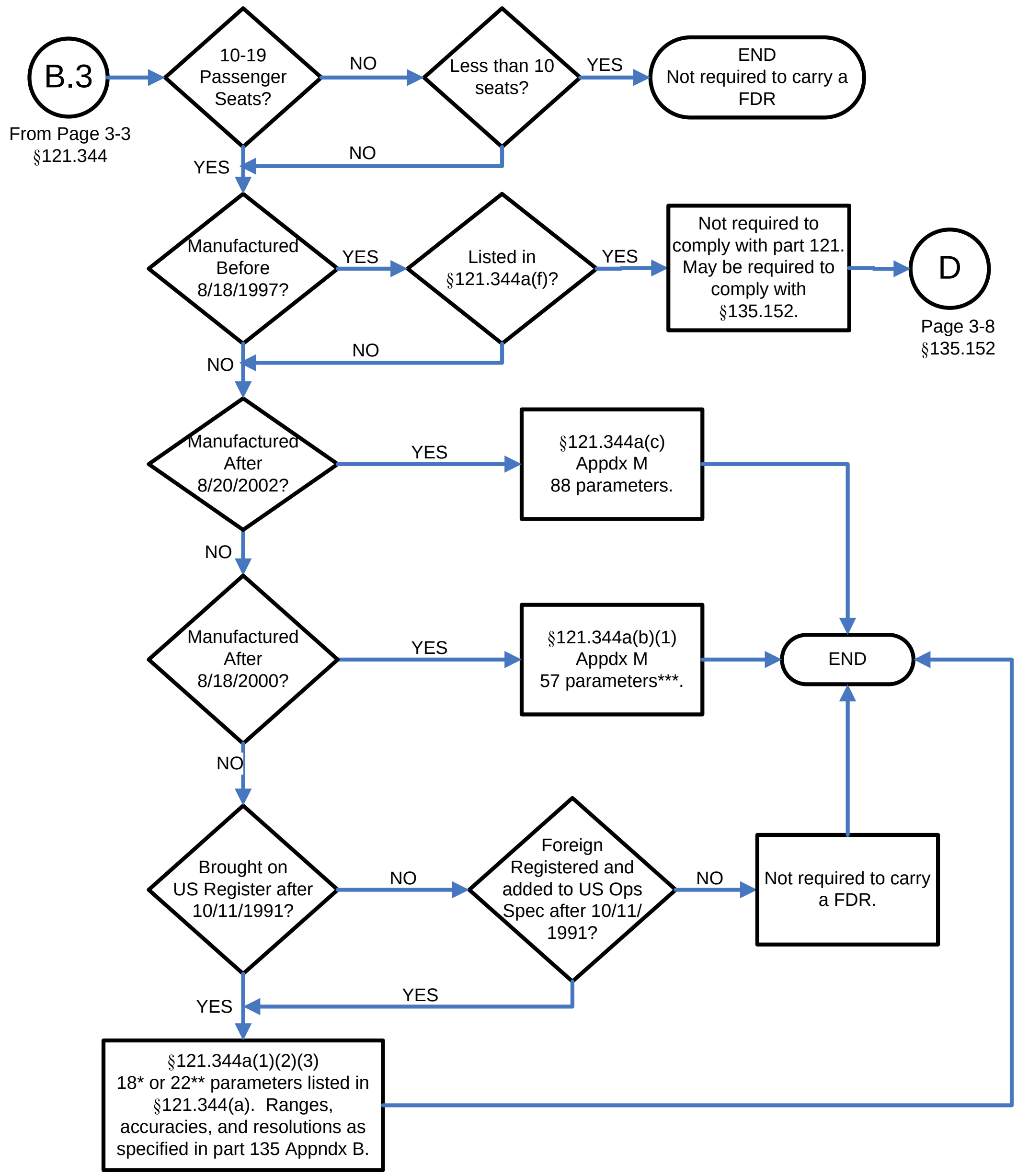


* Commensurate with capacity, any other parameters (of 88) that have information sources installed and connected to the recording system.

Part 121 Flight Recorder Parameter Requirements, §121.343



Part 121 Flight Recorder Parameter Requirements,
§121.344a

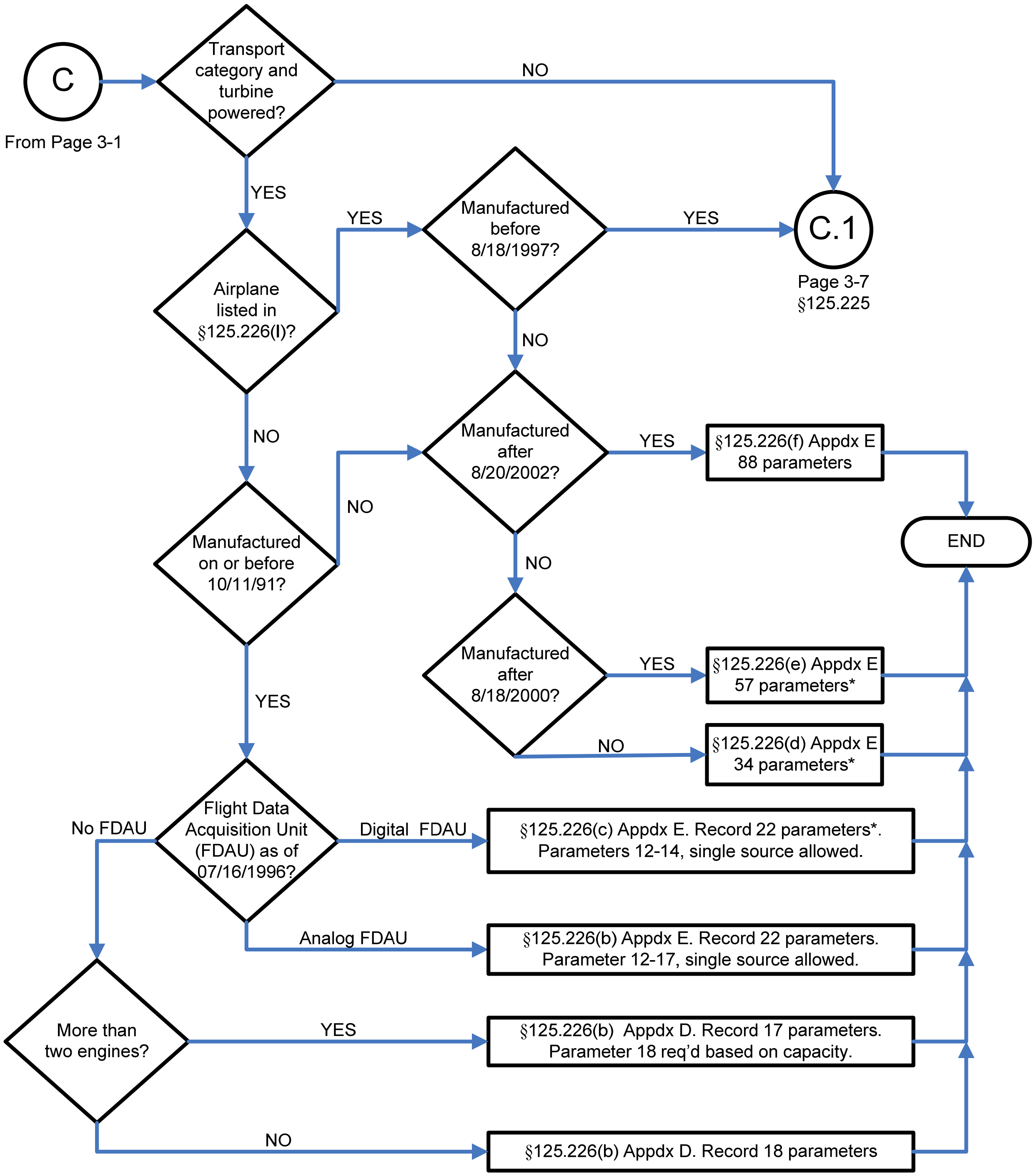


* Either the parameter listed below must be recorded:
§121.344(a)(12) or (a)(15)
§121.344(a)(13) or (a)(16)
§121.344(a)(14) or (a)(17)
For airplanes with more than two engines, §121.344(a)(18) must also be recorded if sufficient capacity is available on the existing recorder.
Parameters §§121.344(a)(12) through 121.344(a)(17) each may be recorded from a single source.

** Commensurate with the capacity of the recording system (FDAU or equivalent and the DFDR).

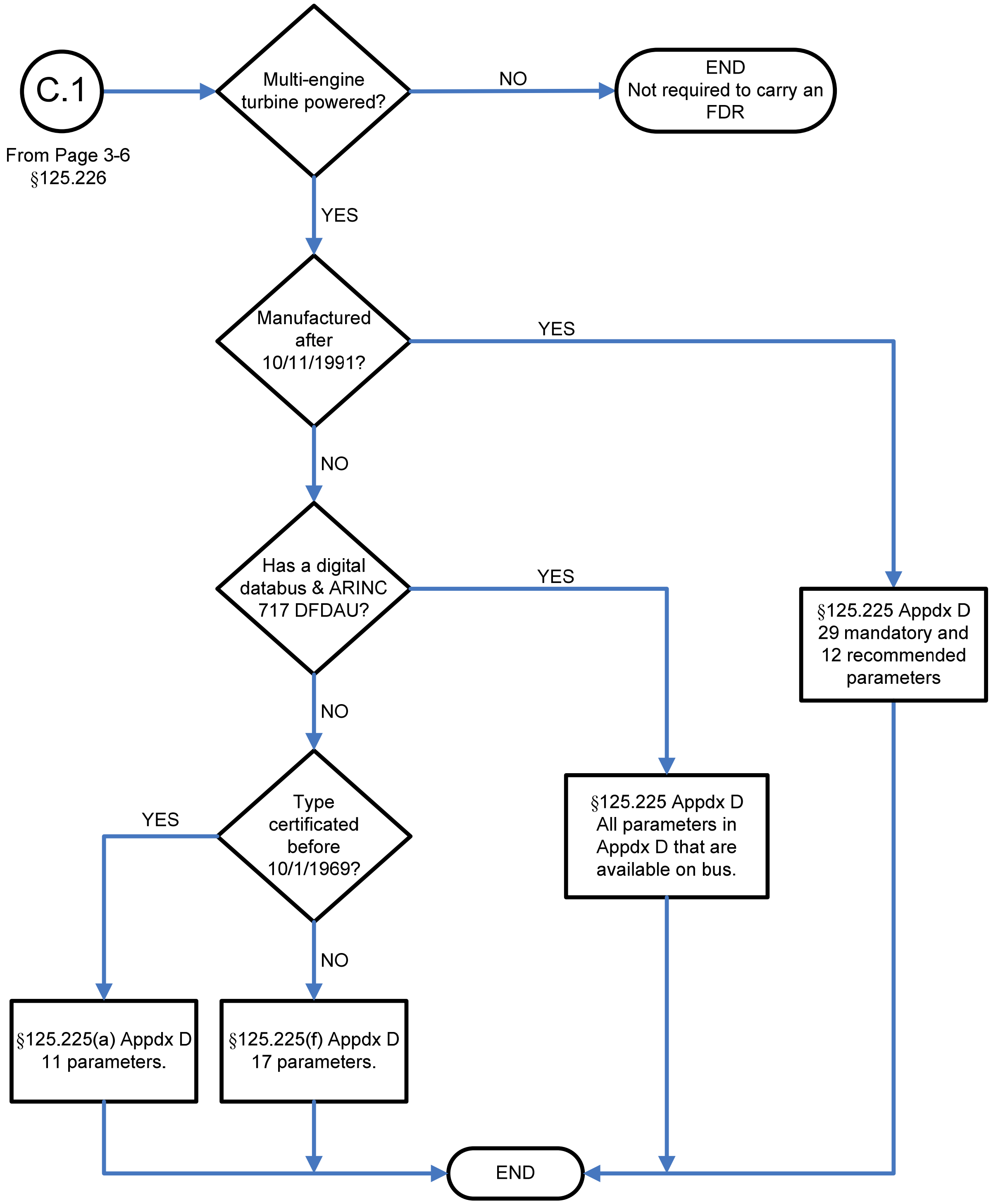
*** Commensurate with the capacity of the recording system, all additional parameters (88) listed in §121.344(a) for which information sources are installed and which are connected to the recording system.

Part 125 Flight Recorder Parameter Requirements, §125.226

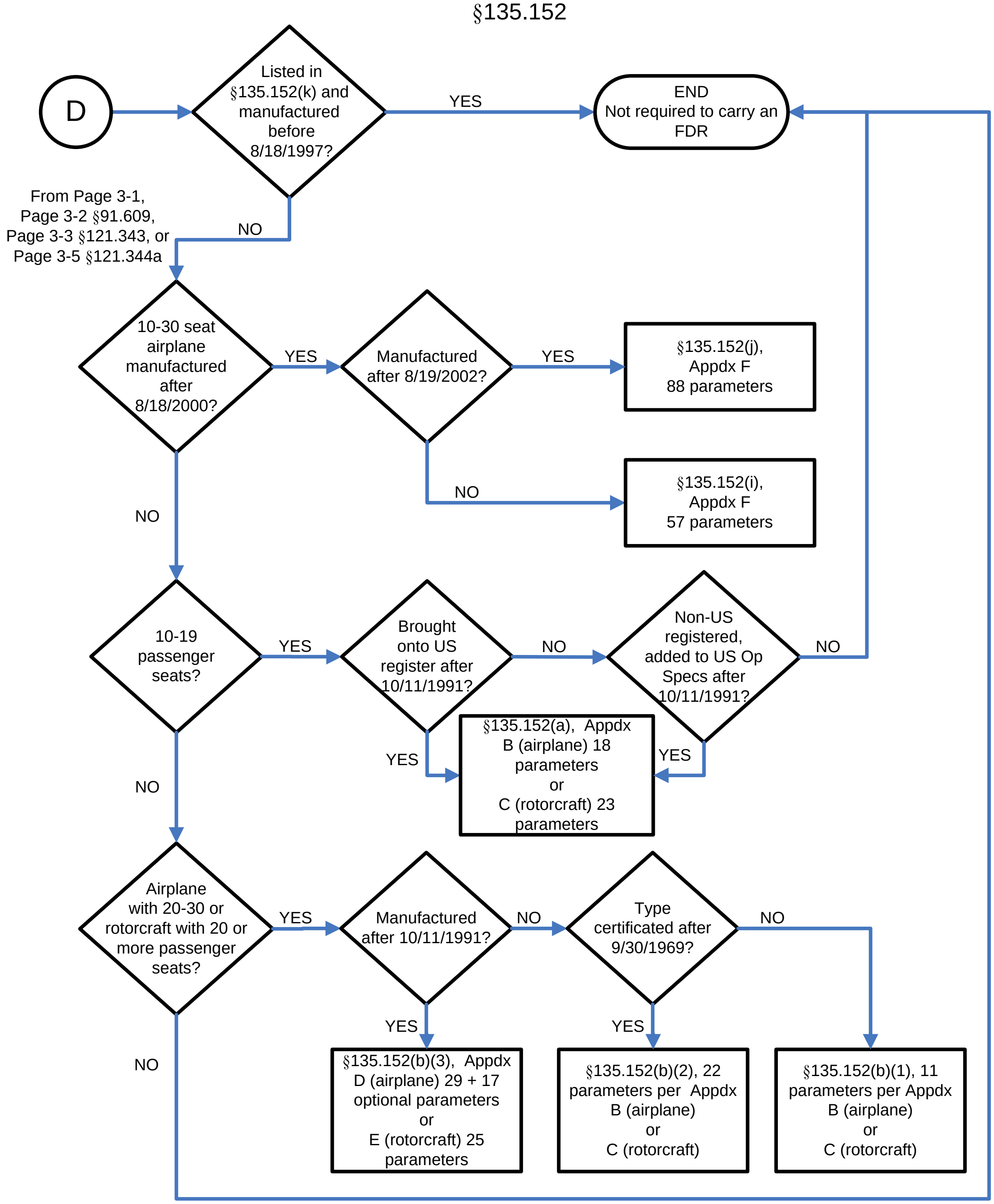


* Commensurate with capacity, any other parameters (of 88) that have source installed and connected to recording system.

Part 125 Flight Recorder Parameter Requirements,
§ 125.225



Part 135 Flight Recorder Parameter Requirements, §135.152



APPENDIX 4. 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 hardcopy. If a hardcopy printout is used, data traces should also be available. The check must be performed using data that has been extracted in EU because octal, BCD, or hexadecimal coded data do 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 confirm that all necessary checks have been accomplished. The checklist must refer the analyst to troubleshooting or repair procedures if a suspect parameter is identified.

3. 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. We recommend that the analyst conduct the review of parameters over several flight segments.

4. 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.

5. 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. Values at their “maximum limit” or that are unvarying indicate an inoperative sensor or other failure. Accelerometers tend to fail at the “maximum limit” position. If the accelerometer trace is not moving during all segments of the flight check, check to see if it indicates maximum or minimum acceleration. An accelerometer failure indicating a mid-point value is uncommon.

6. 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 initiates. There may even be a variation in lateral acceleration. Again, it is important the analyst confirm that that movement is indicated in the proper direction according to the aircraft sign convention. Table 4-1 is provided as an aid to prepare a reasonableness checklist. It summarizes parameters in a 34-parameter DFDRS 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 4-1 in developing a reasonableness checklist for each parameter.

a. Thrust Reverser Position Reasonableness and Quality Check. In Table 4-1, the column labeled Thrust Reverser Positions (number 22) contains check marks in the rows labeled Airspeed, Engine Thrust, Longitudinal Acceleration, Autopilot AFCS Mode, and Air/Ground Sensing. The normal expectation is for 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 data 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 indicate stowed 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. Immediately after the thrust reverser deployed indication, the engine thrust should have increased to near the maximum indication.

(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 mode discrete and the air/ground sensing discrete. The autopilot mode discrete should indicate that the autopilot has 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 allowable values and do not have sufficient duration to be interpreted as an actual deployment.

b. Lateral Control Surface Position Reasonableness and Quality Check. The column labeled Lateral Control Surface Positions 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. When the lateral control position is 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 course null.

(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.

TABLE 4-1. PARAMETER CORRELATION

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
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			✓						✓											✓	✓		✓		✓									■

APPENDIX 5. CONSIDERATIONS FOR FILTERED FLIGHT DATA

RESERVED