# EAC
# No. 121_3

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# QUALITY ASSURANCE PROGRAM

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Since the utilization of operations flight data for safety enhancement of human factors is not prevalent among Egyptian air carrier operators, non-Egyptian operators were used as an informational study base for this advisory circular.

This report provides initial guidance and recommendations for development and implementation of a Flight Operations Quality Assurance Program (FOQA) within the Egyptian air carrier environment. The ECAA will assist any interested carrier with the development of their individualized program.

## CHAPTER 1 FLIGHT OPERATIONS QUALITY ASSURANCE PROGRAM (FOQA)

### SECTION 1 INTRODUCTION

1. **PURPOSE:** This Egyptian Advisory Circular (EAC) provides information and guidance that can be used by air carrier certificate holders, operating under Egyptian Civil Aviation Regulations (ECARs), Part 121, who elect to develop a FOQA Program to enhance flight safety. The FOQA Program is voluntary, but implementation is **strongly** recommended. This program affords a carrier the opportunity to implement a Voluntary Disclosure Reporting Program.

*Note*: Refer to Partnership 2000 Informational Bulletin for complete guidance.

This EAC is primarily intended for use by an operator's flight operations and flight safety departments. FOQA Programs analyze data collected during flight for a pilot's self-improvement, the improvement of airline operations and training, and to increase the safety level of the national airspace system.

*Note*: Information from cockpit voice recorders is **not** used in the FOQA Program.

The ECAA encourages certificate holders to develop and implement FOQA Programs as a tool for continuously monitoring and evaluating operational practices and procedures. The ECAA has stated that public safety is enhanced if deficiencies are identified and immediately corrected upon discovery by the certificate holder rather than discovery by the ECAA. FOQA Programs are designed to provide quantitative and objective information necessary to identify these deficiencies.

The definitions and program elements outlined in this EAC are consistent with successful programs implemented by a large number of non-Egyptian air carriers.

2. **BACKGROUND:** The ECAA recognizes that air carriers perform their services with the highest possible degree of safety. In support of this safety objective, the ECAA has publicly endorsed FOQA Programs as a means to enhance training programs, flight crew performance, operating efficiency, air traffic control, aircraft/airport design, and other safety related programs.

The FOQA Program is based on the premise that air carriers have the primary responsibility for continuously monitoring their operations and ensuring that they are safe and in compliance with current operating standards and the ECARs. The FOQA Program will assist certificate holders in identifying and addressing operational deficiencies and trends that are not generally detectable with other procedures or programs. The availability of certain FOQA Program data to certificating authorities, manufacturers, and airport operators will contribute to improving the overall safety and efficiency in areas related to their specific objectives.

FOQA users agree that insights derived from these programs have prevented serious incidents/accidents and led to improved operating efficiencies. Manufacturers of large jet transports have also endorsed FOQA as a means to enhance safety by improving operating procedures, crew training, and aircraft design.

A FOQA Program not only helps to identify and correct deficiencies in flight crew training and operating procedures, but also leads to the development of an automated industry safety database. Inter-airline sharing of FOQA information will enhance the level of safety for all participants.

3. **REFERENCES:** A FOQA study report entitled, “Air Carrier Voluntary Flight Operational Quality Assurance Program”, prepared by the Flight Safety Foundation, located in the United States, is the basis for the information contained in this EAC. The ECAA encourages air carriers to review this report regardless of whether or not they intend to implement a FOQA Program.

## SECTION 2 DEFINITIONS AND GLOSSARY

4A. **Airborne Data Acquisition Equipment:** Electronic data processing equipment that satisfies a wide range of requirements for aircraft flight data recording. It provides acquisition and signal conditioning for a variety of aircraft parameter sensor types and performs conversions for transfer of data to a Digital Flight Data Recorder (DFDR), or other device. The most common types are:

1) Flight Data Acquisition Unit (FDAU): Used with original ECAA-mandated DFDRs. It was designed to accept analog data inputs per ARINC 573 design specifications.
2) Digital Flight Data Acquisition Unit (DFDAU): Second-generation processing equipment that accepts digital data (ARINC 429) and includes microprocessors that can be programmed to analyze data and generate reports. Units that meet ARINC 717 design specifications are available but have limited solid-state storage capacity.
3) Flight Data Interface Unit (FDIU): Performs functions similar to a DFDAU.
4) Digital Flight Data Acquisition Card (DFDAC): A single circuit card that performs the function of a DFDAU and provides processed data to the DFDR.

4B. **Aircraft Integrated Monitoring Systems (AIMS):** A class of airborne data acquisition and management systems, with varying capabilities, that provides recorded flight data on the operation/performance of the aircraft, engine and on-board systems. Data systems that are included in this definition are:

1) Aircraft Integrated Data Systems (AIDS);
2) Aircraft Condition Monitoring System (ACMS);
3) Auxiliary Data Acquisition System (ADAS);
4) Flight Data Acquisition and Management System (FDAMS); and,
5) Aircraft Recording and Monitoring System (ARMS).

4C. **ARINC Communication and Reporting System (ACARS):** An addressable digital data-link that permits two-way communication of information on an ARINC Very High Frequency (VHF) radio network. Data sent and received on the ACARS network reduces communication errors and decreases the number of required voice transmissions by flight crews, thus enabling them to better focus on other flight duties.

4D. **Data De-Identification:** Removal of any recorded information that could be associated with a particular flight, date, or crewmember.

4E. **Data Management Unit (DMU):** Performs the same functions as an acquisition unit. It provides advanced capabilities for on-board analysis, report generation, and data transfer to peripheral devices. Expanded solid-state memory provides substantial storage for in-flight reports. In most cases, DMU software programs accommodate floppy disks.

4F. **Data Transcription:** A software process that transforms recorded data into synchronized frames of binary bits that are representative of the bit sequence originally fed to the recorder by the FDAU or DFDAU. Data recorded on a flight recorder is encoded, generally in Harvard biphase or bipolar format. In other words, Data Transcription is an analog recording of a digitally encoded data stream.

4G. **Data Validation:** A process that reviews the event report data to ensure it was not generated as a result of erroneous data or damaged sensors.

4H. Event Levels: Classifies the degree of exceedance, from the established norm, into two or more severity categories.

4I. Exceedance Envelope: Defines the limits that will trigger an exceedance report for a particular operational event.

4J. Exceedance Plot: A two-dimensional plot of the exceedance and event-related flight parameters recorded during several minutes of flight.

4K. Flight Data Analysis Programs: Software applications that are designed to process and scan selected flight data parameters. They compare recorded or calculated values to predetermined norms by use of event algorithms. When exceedances are identified, reports are generated for review or trending.

4L. Flight Operations Quality Assurance (FOQA): A program that obtains and analyzes data recorded in-flight. The analyses and resulting follow-up actions lead to an improvement in flight crew performance, training programs/operating procedures, air traffic services procedures, airport maintenance/design, and aircraft operation/design.

4M. Quick Access Recorder (QAR): Records AIMS data and has provisions for quick extraction of data on a medium that is easily transportable.

4N. Glossary

- **ACMS** - Aircraft Condition Monitoring System
- **AIDS** - Aircraft Integrated Data System
- **AIMS** - Aircraft Integrated Monitoring System
- **ATS** - Air Traffic Services
- **DFDAU** - Digital Flight Data Acquisition Unit
- **DFDR** - Digital Flight Data Recorder
- **DMU** - Data Management Unit
- **DRU** - Data Recovery Unit
- **FDAU** - Flight Data Acquisition Unit
- **FOQA** - Flight Operations Quality Assurance
- **IEP** - Internal Evaluation Program
- **OQAR** - Optical Quick Access Recorder
- **QAR** - Quick Access Recorder
- **STC** - Supplemental Type Certificate
- **TC** - Type Certificate

## SECTION 3 OVERVIEW

**3. PURPOSE AND OBJECTIVES OF A FLIGHT OPERATIONS QUALITY ASSURANCE PROGRAM:** To improve flight safety by providing information and insight into the total flight operations environment through selective automated recording and analysis of data generated during in-flight operations. Analysis of data will reveal situations requiring improved operating and training procedures, equipment, or supporting infrastructure.

Current FOQA users have indicated that integrating the FOQA process into routine operations enhances flight safety and operational efficiencies. Information derived from FOQA Programs is also able to complement engineering/maintenance programs.

ECAA-mandated DFDRs record data on flight crew performance, weather, aircraft systems, engine operation and Air Traffic Services (ATS) for use during accident investigations. One element missing from this process is quantitative information concerning <u>operational incidents</u>, which occur more frequently, and are often the precursors of accidents. Accident statistics indicate that approximately 70 percent of worldwide hull-loss accidents involved flight crew errors. However, these errors are often linked to other accident-enabling factors. A FOQA Program can detect, analyze, and correct these factors, thus reducing the overall risk to flight operations.

The specific objectives of a FOQA Program are to:

i. Collect operational flight data to identify improvements necessary in training programs, ATS, and aircraft/airport design;
ii. Evaluate and review the performance of flight crews;
iii. Compare the collected data with established procedures and standards;
iv. Develop exceedance information;
v. Perform trend analyses of exceedances to evaluate corrective actions and measure performance over a period of time; and
vi. Use analyzed data in formal awareness and feedback programs to enhance safety in the following areas:
    - Flight procedures;
    - Flight training procedures;
    - Crew performance during all phases of flight;
    - Air Traffic Services procedures;
    - Cockpit crew interface with aircraft systems; and
    - Aircraft/airport design and maintenance.

## 6. CONCEPTUAL ELEMENTS OF A FOQA PROGRAM:

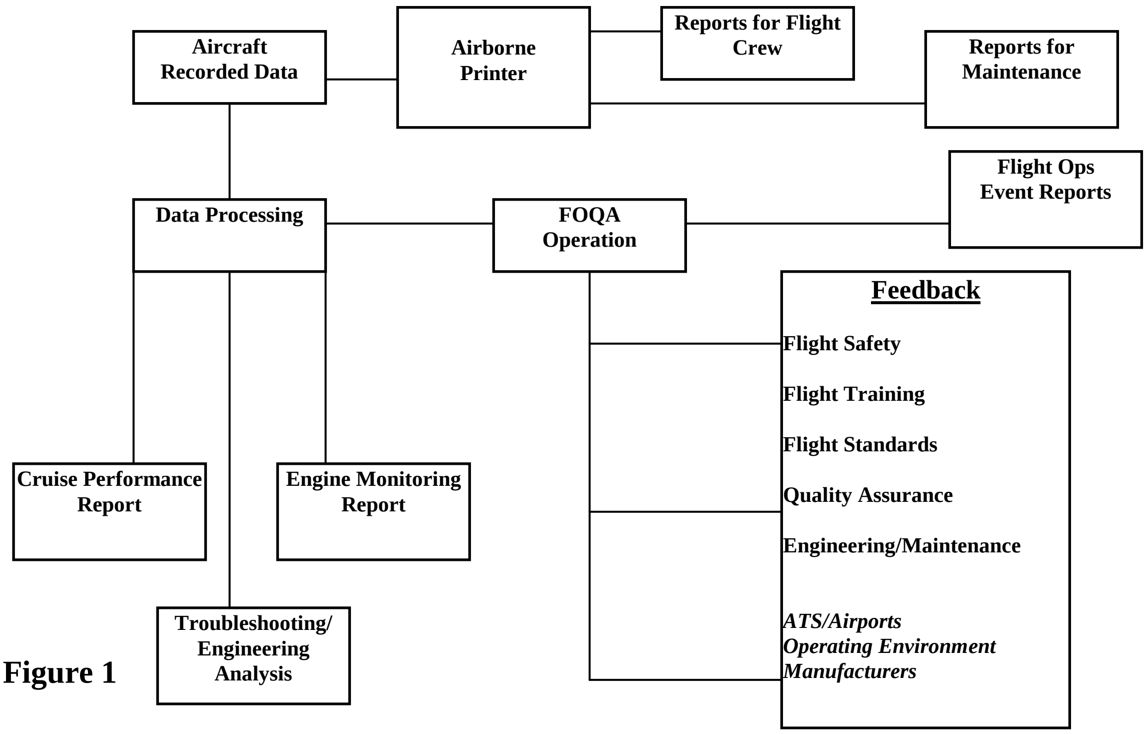



**Figure 1**

Figure 1 illustrates the flow and processing of FOQA data recorded in-flight and the air carrier organizations involved in FOQA management.

7. **PROGRAM APPLICATION:** FOQA Programs are recommended, on a voluntary basis, to all Part 121 operators of large jet transport aircraft. Other operators, with capabilities to monitor FOQA parameters, are also encouraged to implement a FOQA Program.

8. **PROGRAM BENEFITS:** A FOQA Program will provide the data and analyses necessary to implement:

- Modifications to operating procedures and training programs;
- Revisions to ATS procedures;

- Fuel savings resulting from use of airborne winds and temperatures for flight planning;
- Improved engine and aircraft performance assessment;
- Improved weather analyses;
- Monitoring of Ground Proximity Warning Systems (GPWS), Traffic and Collision-Avoidance Systems (TCAS), Windshear Warning Systems, and Autopilot Systems;
- Resurfacing of rough runways; and
- Support of aircraft certification and research programs.

9. **MANAGEMENT:** The management organizational structure of FOQA Programs (Figure 2) should be established within flight-operations related departments. These departments are better equipped to address the safety priorities associated with FOQA.

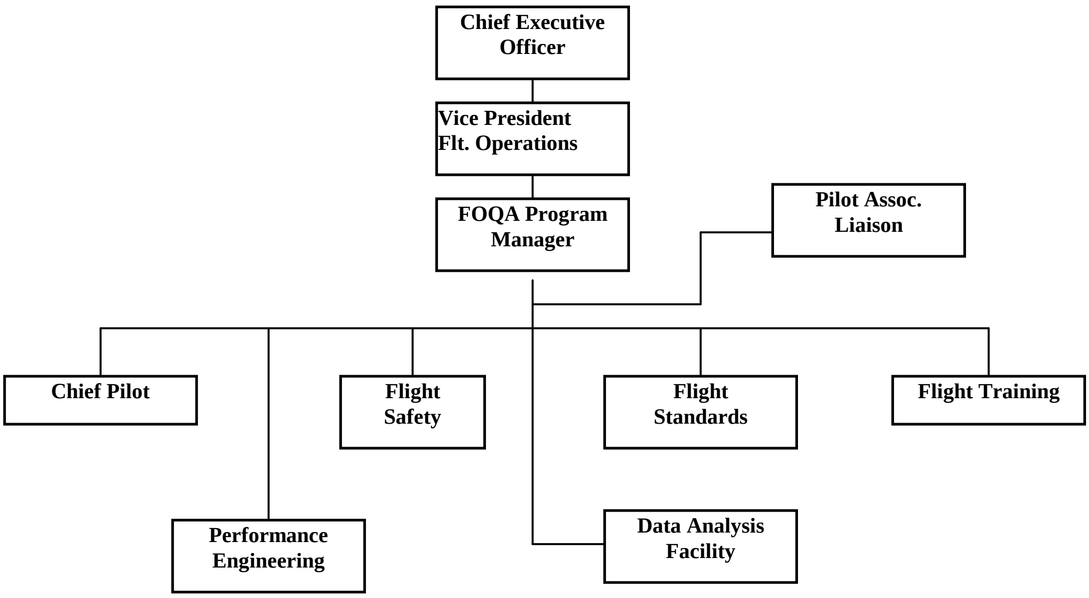



**Figure 2**

# <u>CHAPTER 2</u> FOQA PROGRAM PLANNING AND DESIGN

This chapter describes the general process for development of a FOQA Program. Design considerations include not only the FOQA Program, but also the interfacing systems that might already be on-board the aircraft.

## SECTION 1 FOQA PROGRAM ELEMENTS

### 10. FOQA ELEMENTS ILLUSTRATION

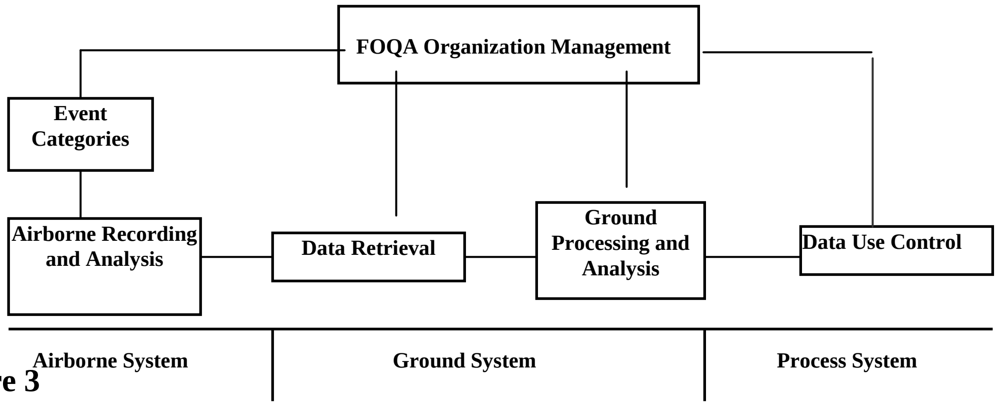



**Figure 3**

11. **FOQA PROGRAM:** Composed of three major elements: <u>airborne</u>, <u>ground</u>, and <u>process</u> systems. The airborne and ground elements consist of hardware and software components. The process element supplies the methodology by which the data is produced and analyzed.

12. **AIRBORNE SYSTEM:** May have a variety of parts depending on operator hardware choices, the airplane data systems provided by the manufacturer, and the systems added to the basic airplane. Regardless of the configuration, the basic purpose of the airborne hardware/software is acquisition and storage of data for later processing and analysis.

13. **GROUND SYSTEM:** Processes the recorded data into required formats, performs analyses, and produces the reports for additional analysis and action. Ground equipment varies widely in size and complexity. If the FOQA Program is integrated into an existing large data system, such as an Aircraft Condition Monitoring System (ACMS), it will most likely be centrally located and use a large computer. If it is a stand-alone FOQA Program, it will likely be PC-based and may have either single or multiple processing locations.

14. **PROCESS SYSTEMS (Divided into Two Elements):** 1) The <u>operations processes</u>, which are necessary to make the program functional and 2) the <u>protection processes,</u> which preclude data use for other than safety or operational purposes. Operating processes include control of data production and data evaluation. When remedial actions are initiated, feedback/follow-up ensures that problems are resolved.

15. **INTERFACING SYSTEMS:** In most FOQA applications, particularly in advanced-technology (glass-cockpit) aircraft, the FOQA Program will depend on input from other data systems in the airplane. In older, unsophisticated fleets, many measurements will continue to be derived from an interface with the DFDR. Modern aircraft rely on dedicated aircraft digital data buses for data inputs and the airborne subsystem selects the desired data from a myriad of bus information. Individual parameters on these complex data buses number in the thousands.

## SECTION 2 ORGANIZATION AND MANAGEMENT

16. **ORGANIZATION:** The organization and management of FOQA Programs should be established within a flight-operations related department. There are currently many program variations depending on how long the program has been established, personnel agreements, aircraft system capabilities, airline organization, and other factors.

Many FOQA activities are conducted jointly with other routine airline activities. Several established programs have ground processing and analysis facilities (located in a maintenance area) that serve both maintenance and FOQA functions. Approximately one third of FOQA users have PCs dedicated to FOQA data processing. This is particularly true of operators beginning with a small FOQA management structure. Varying degrees of management participation and expertise are utilized in the event review and feedback action processes required to address negative trends.

FOQA activities are conducted outside normal airline operations because of the commitment to address FOQA data with a high degree of confidentiality and control. The duties and responsibilities of the FOQA Program Manager are based on control and use of event data. Specific activities may include:

- Administration of the program and liaison with pilot groups;
- Establishment and control of program policies/procedures;
- Event evaluation and follow-up;
- Feedback/coordination of safety trends;
- Maintenance/security of trend and exceedance databases;
- Software maintenance and configuration control;
- Software modifications related to event categories and trigger levels; and
- Coordination of critical operations data with maintenance/engineering..

17. **DATA USE AGREEMENTS:** Formal agreements are generally required between the airlines and cockpit crew associations. Agreements have existed since flight data recorders were required by 1950s legislation to support government investigations of accidents and incidents. Expanded uses of DFDR data in FOQA Programs have resulted in modifications to the language of these agreements. In most cases, the agreements are general and focus on protection of the flight crew from punitive action. The most common provisions of these agreements are:

- Individual protection;
- Data use;
- Data access;
- Use of data with ACARS; and
- Crewmember identification.

Recent agreements have been very specific and discuss how the data is processed, managed, evaluated, de-identified, and retained. Most agreements lack definitive language concerning circumstances in which a crewmember would be identified or contacted. This is usually subject to a company and labor review on a case-by-case basis and always involves a FOQA representative appointed by the pilot group.

18. **DATA PROTECTION AND SECURITY CONSIDERATIONS:** The issue of data protection and security is sensitive and focuses on data that can be identified with a particular airline, flight, date, or cockpit crew. **Any use of identified data for purposes other than safety enhancement is counterproductive to achieve program goals**. Restrictions placed on identified data arise from pilot and management agreements. Management must honor these agreements and preclude use of the data for punitive action, thus ensuring that safety improvements, provided by the program, are preserved.

Management's responsibilities include the identification/investigation of operations irregularities and the modification of operations, procedures, and training when deemed necessary. This can only be accomplished if there is an information flow from the involved cockpit crews that provides insight into the causal factors associated with an event. Thus, labor and management usually agree on a set of policies and procedures to control and restrict access to any data that is considered sensitive. These policies and procedures govern all processing of the data after an event has been identified. They determine when and how the data is to be used, who will have access, and the time frame/format for retention.

Confidentially, Anonymity and De-identification, are terms relevant to the use of FOQA data.

Confidentiality assures that only authorized personnel have access to FOQA data. Documented provisions outline rules and procedures to ensure full examination of exceedance events.
Anonymity precludes identification under any circumstances. However, in order to enhance safety and when deemed appropriate, cockpit crews should have the opportunity to provide additional information.
De-identification removes crew names, flight numbers, dates, and airline identities from the database.
A FOQA Program must operate in an environment that encourages the voluntary submission of additional information as each situation may suggest.

**PROTECTION CONSIDERATIONS**

Data control is accomplished by restricting access to the data. These controls include:

- Locked and restricted entry to data playback and analysis facilities;
- Passwords for analysis software applications and database files;
- De-identification of data;
- Limited dissemination of identified reports and plots; and
- Selection of personnel with a high degree of integrity.

***Note*: Airlines should coordinate the selection of key FOQA participants with their pilot groups to maintain effective working relationships.**

Data de-identification **should** include airline, flight number, date, and cockpit crew. Data may be in a computer file or in a collection of detachable data strips that have been removed from the event reports. Identifying information should be retained only until the event has been analyzed and understood. It should be securely stored and physically separated from the data printout or plot.

**SECURITY CONSIDERATIONS**

Security must be maintained with data that is retained beyond the period required to investigate an operational event. This period may vary to accommodate individual airline requirements and philosophies. The sensitivity of information is reduced when it cannot be identified with a particular flight, thus diminishing security requirements.

**SECTION 3: HARDWARE AND SOFTWARE SYSTEMS**

18. **Airborne System Configurations:** Airborne system vary greatly depending on the manufacturer of the aircraft, date of manufacture and the equipment selected to be installed on the aircraft. **Appendix 2** gives a detailed explanation of the different types of airborne systems installations.

The reporting available is dependent on the type of system installed. The typical report options that are available include:

- Takeoff Performance;
- Climb Performance;
- Flight Analysis;
- Turbulence;
- Engine Condition Monitoring;
- Cruise Performance;
- Landing;
- Autoland; and
- Flight Summary.

These are not considered FOQA reports and mostly involve engine and aircraft systems information used by the airlines for maintenance. Exceedance reports also would be generated if a programmed maintenance parameter limitation is exceeded. For example, engine pressure ratio (EPR), exhaust gas temperature (EGT), engine overspeed, and vertical acceleration are all examples of parameters with operational limitations that trigger a maintenance action report. Typically, 50-60 routine reports are programmed to meet user needs and, for several systems, as many as 100 reports may be established. Several systems can be temporarily reprogrammed with additional parameters for special trending or troubleshooting. This is useful for investigation of system irregularities that may occur only during flight.

Data compression within the DMU has increased QAR recording capacity. Data compression requires complex mathematical processing of the variations in a parameter to reduce the data that must be recorded. For example, a parameter that remains stable for several hours, such as altitude, could be recorded as two data points and an intervening time, thus reducing significantly the amount of tape that would be required to record this one parameter for the same period.

20. **DATA EVENT CATEGORIES:** Operational conditions selected for monitoring and review. These conditions include a broad range of aircraft and engine system characteristics, such as, system and mode status, performance limitations, flight control system inputs and responses, rates of change, and event duration.

For example, an event category could be "rate of descent on approach." Typically, several subevents would be defined within this category and would become progressively less tolerant of deviations as the aircraft descends to the ground. Some events are aircraft-specific either because they are only applicable on certain aircraft, or associated with a unique flight control or flight management system.

In maintenance, the selection of events will focus on:

- System information related to maintenance reliability;
- Manufacturers' warranties;
- Aircraft and engine performance documentation for operational usage compliance, e.g., Extended Twin-Engine Operations (ETOPS) or autoland systems; and,
- Systems troubleshooting.

Most maintenance-oriented conditions, including exceedance levels, are programmed for documentation purposes. Many parameters are only recorded periodically, however, critical parameters are monitored constantly for exceedances, particularly those that affect the engines or aircraft structural integrity.

In contrast, the monitoring of flight operations variables will focus almost totally on situational exceedances that vary by phase of flight. The primary concern is operational excursions of the aircraft and flight control systems from standard operating procedures. Most of these require the sensing of multiple parameters, although the exceedance trigger is generally a single parameter. Some variables are simply the operating limitations of the aircraft, but most relate to the training and operating policies/procedures of the individual operator.

Analyzing safety issues in accidents/incidents and proposing subsequent exceedance categories will assist in the development of event categories. Current FOQA event categories have evolved from those identified by initial FOQA users. Subsequent users incorporated modifications and expansions to these categories. The events adopted by most users parallel standard training and flight-check syllabi. However, generating practical event envelope limits has required appreciable trial and error in the collection of empirical flight data. Many other events are monitored only for maintenance. While event categories are relatively consistent across a user's fleet, every user does not monitor all event categories and many experienced users continue to adjust thresholds on several parameters.

## MOST COMMON EVENTS

**TAKEOFF**

- Rotation speed
- Vertical accel.
- Rotation rate
- Pitch attitude
- Unstick speed
- Abort

**CLIMB**

- Climb speed
- Alt loss
- Bank angle
- Pitch attitude
- Vertical accel
- Time to 1,000 ft
- Gear up speed
- Flap/slat config

**CRUI**

- V
- M
- M
- Ba

**MULTIPLE FLIGH**

- Abnormal flap/s
- Vertical accelera
- Bank angle
- Flap placard
- Stick shaker
- Ground proximit
- Birdstrike speed
- Pilot event mark

21. **PARAMETERS AND EXCEEDANCE LEVELS:** A parameter is a measurable variable that supplies information regarding the status of a system or subsystem. As an example of the relationship of parameters to events, consider an event category called "excessive pitch rate on takeoff rotation." On older aircraft, pitch rate data is not available directly and must be derived by monitoring pitch-attitude variations. Also, the air-ground sensor (squat switch) data is needed to determine when the aircraft leaves the ground. In this case, data from three parameters (pitch-attitude, time, and air-ground sensors) would be required to define a single event.

Users have limits in selecting an ideal set of variables to monitor. The number and types available for a particular aircraft are based on:

- Mandatory DFDR parameters;
- Parameters provided by the aircraft manufacturer as part of the basic system configuration;
- Parameters selected as change/request options on new aircraft purchases; and
- Fleet modifications.

Required DFDR data has a specific set of parameters with specific sample rates and accuracies. These parameters are cross-utilized by distinct data acquisition units that separate the ECAA required data from voluntary FOQA data. The availability of critical parameter signals influence how specific aircraft can be used in a FOQA Program. Most current users selected Data Acquisition/Management Systems with extended parameter wiring at the time of aircraft purchase.

22. **RETRIEVAL EQUIPMENT AND OPTIONS:** Although there are several options for removal of recorded data from the aircraft, there are limited options for retrieving FOQA data. Data can be retrieved through QAR magnetic tape cassettes, optical disk, floppy disk, data loader, printer, CRT display or data link. Because of the earlier availability of tape systems and the ease of data removal, many current FOQA operators use tape QARs. Spares can be maintained on the aircraft to facilitate data cassette exchanges at line stations.

There are no special equipment requirements for manual removal of a cassette, but there is a requirement in the ground system for a Data Recovery Unit (DRU). The DRU serves as a data input reader when it is interfaced with the ground playback system. These units usually can be used with PCs and are supplied by the QAR manufacturer.

23. **GROUND PLAYBACK EQUIPMENT:** Transforms the raw digital flight records into usable form for review and trending. This equipment has extensive variations and is usually capable of handling a variety of recorded data formats and recorder types.

The DFDR and FDAU manufacturers initially developed the playback equipment to process FOQA data. The original equipment used mainframe computers, but current technology allows PC based processing and analysis.

Basic functions of the playback equipment are similar, regardless of specific devices selected. Data readers/recovery units read and transfer the data from the recorded medium; computer processors and storage devices receive, reformat, and store the data; and dedicated processors, programmed with software applications, transcribe and analyze the information. Data storage is accomplished with magnetic tape, floppy disks, optical disks, hard drives, or solid-state memory. Peripheral output devices include printers, plotters, strip chart recorders, and CRT displays. The restrictions on the handling of FOQA data influence the organization/operation of playback facilities and equipment selection.

## SECTION 4 OPERATING PROCESSES

24. **DATA COLLECTION AND RETRIEVAL:** There are two basic approaches to recording FOQA data. One method is to record raw data in-flight for the selected parameters and then process the data using a ground replay station for event exceedance analysis. The second method is to record data and perform real-time in-flight analysis only when an exceedance occurs. This has the advantage of substantially reducing the data that must be processed and reviewed on the ground, but has the disadvantage of losing expanded pre-event and post-event information that might be useful for complete understanding of an event.

Raw-data recording requires most users to use data compression or intermittent recording because of limited QAR capacity. Full recording is common for takeoff, initial climb, and approach/landing. Intermittent recordings are normally made during cruise flight.

In-flight recording and analysis requires on-board equipment that is programmed to record selected events and associated limits. Such equipment and capacity is found only with state-of-the-art systems. During operation, a full set of programmed parameters is continuously scanned, in real-time, and the data is transferred to a short-term buffer memory in the DMU for temporary storage. During scanning, the parameters are evaluated for event exceedances. If an event is triggered, a segment of the stored pre-event parameter data is recorded, along with the actual and post-event data. The amount of recorded data is variable and can be programmed to be as much as plus or minus three minutes from the exceedance time. These are referred to as event snapshots because the data provides only a short, bracketed view of the event. Most users prefer full in-flight recording and ground analysis, in addition to event snapshots, to insure that all of the historical data is available for later detailed analysis.

Routine retrieval of data from the aircraft is accomplished by removal/replacement of a QAR cassette. The operator's maintenance personnel usually conduct this procedure. The cassettes must be removed daily because they contain a limited amount of data; otherwise, previously recorded data could be overwritten with new data. Spare cassettes may be stocked on the aircraft or at maintenance line stations.

25. **DATA REDUCTION AND ANALYSIS:** Data reduction involves processes required to convert the data into a format that is easily reviewed. The type and degree of ground processing depends on the medium and format in which the data has been recorded.

Transcription transforms the recorded data format into a binary bit stream that is reformatted and synchronized to the original FDAU or DMU data structure. The transcribed file is stored on magnetic tape, optical disk, floppy disk, or other medium. It is then analyzed by software applications that apply conversion algorithms to the appropriate binary data words to produce engineering unit values (parameters). These values are then compared to event limits for exceedance evaluation.

Usually the software applications are purchased from the equipment manufacturers, but occasionally, users develop customized applications. In either case, these applications offer a variety of procedures that can be customized to meet the needs of an individual operator.

Most FOQA users install software programs that automatically scan the transcribed data for event exceedances and other programmed data generated during flight. This analysis could require 30-40 minutes, depending on the efficiency of the software and the processing power of the playback computer. Event reports are automatically generated as the transcription files are scanned. Scanning may be accomplished overnight while the facilities are unattended. The format of the event reports can be a blocked listing of pertinent flight information or a flight profile reproduction of selected event-related parameters. The posted information will generally include flight number, date, aircraft tail number, flight origination/destination, time of event, and category of event.

In addition to data processing and generation of event reports, software analysis applications must perform other functions. Options for data display include flight profile plots, engineering unit listings, and multiple parameter x-y graphs. Graphic cockpit symbols and color three-dimensional (3-D) flight simulation may be the most effective methods to communicate flight path and profile information for pilot feedback and training.

26. **EXCEEDANCE AND EVENT TREND ASSESSMENT:** Each user should develop procedures that follow organizational structure and management requirements. The most important element is strict adherence to established review and action procedures. **Committee participation in this review must include cockpit crew representation.**

The FOQA Manager should perform a daily review of the event reports generated from the previous day's processing operation. In most instances, only the more serious alert level event reports would be generated as full reports. Most of the events will fall into a less significant category and will be fed automatically to the trending database. It may be preferable to print only special category events accompanied by a tabular event listing of peak parameter values for all other types. The objective in each case is to concentrate on the more serious events. In practice, relatively few events exceed the bounds of operational tolerance.

Procedures are necessary to review and validate the event reports. Technically and operationally qualified individuals should conduct these reviews.

After validation, the event is evaluated to determine if trend analysis is required or if it is an excursion warranting further review and possible feedback from the crew. If there is any indication that the aircraft may have suffered structural stress, engine damage, or other adverse problems, the appropriate engineering or maintenance department should be notified immediately. If feedback from the cockpit crew is necessary, several alternative procedures may be followed. Users can establish a formal process of committee review to reach a consensus on the need to contact the crew. Alternatively, a user may simply provide the event information to the Chief Pilot and request that he identify and contact the crew for feedback.

Although not all FOQA users employ committees to make the crew-contact decision, all users should have some form of event-review committee that meets periodically to discuss events and trends. These committees would typically be composed of management representatives from flight operations, flight training, flight standards, flight safety, performance engineering, and representatives from the pilot group. The schedule for these committee meetings varies among users, but is usually monthly. However, serious events should be resolved immediately. Any additional concerns should also be discussed during the committee meeting and further action taken when appropriate.

27. **DATA FEEDBACK AND RESULTANT ACTIONS:** Corrective actions may be reflected in revised training methods, pilot bulletins, pilot briefings, company procedures, ATS procedures, flight standards procedures, airport bulletins, and navigational chart improvements. In some cases, modification to training programs or operational policies and procedures may be required.
Fleet training managers and check airmen should also be involved in the timely dissemination of operational changes. Periodic reviews of negative trends are conducted in much the same way as other flight safety or quality assurance processes.

28. **TRENDS AND RECORDS RETENTION:** The value of FOQA Programs is the early identification of flight trends that indicate a deterioration of operational integrity. Users permit this data to be used only for safety enhancement purposes and obtaining vital operational information that would otherwise be unavailable. Trend data is used to indicate when and where operational changes are necessary. The trend databases are arranged to enable the user to evaluate trends for each event severity level. Selected individual identifying characteristics are removed, but data may still be associated with an aircraft type, flight origin, destination, and month. The database may be analyzed using an off-the-shelf software application or a multipurpose user developed program. Trend capabilities are usually designed into the FOQA analysis applications offered by equipment manufacturers and suppliers. These software applications apply, sort, and trend information by keywords.

FOQA data may be retained in one or more of the following categories: identified, trend, or archived.

<u>Identified Data</u> generally has associated records that could be correlated to a specific flight. All FOQA data falls into this category when it is initially reviewed. The retention period should be as brief as possible. Operators may choose to retain all aircraft raw data or only peak exceedance values.

<u>Trend Data</u> is usually retained for several years. It is maintained on tape or disk drives and may be linked to a mainframe computer storage system. Data includes peak values for the related events, as well as, a wide range of flight and event related elements. However, trip and date information are not included.

<u>Archived Data</u> is retained for special studies that might be considered important later as a result of a new safety issue or reexamination of a previous one. De-identified data is particularly valuable in exploring unresolved issues as additional information becomes available. To satisfy these objectives, the archived data generally is the complete raw data records.

29. **SOFTWARE CONSIDERATIONS:** The continued effectiveness and value of a FOQA Program are dependent on its ability to adapt to changing fleet compositions, system configurations, flight operating procedures, and operational variations.

Menu-driven edit programs are provided as standard packages or options for most of the referenced requirements. Ground-based analysis software options may include:

- Menu-driven instructions only, for which the operator must do the programming;
- Starter kits that provide a complete set of basic parameter tables and event algorithms with instructions for further expansion; or
- Complete event program packages customized to operator requirements.

## SECTION 5 STAFFING CONSIDERATIONS

30. **STAFFING ESTIMATES:** In establishing FOQA Program staffing, an airline must consider whether to conduct in-house data analysis or contract with an outside service. This decision depends largely on the scope (objectives, fleet composition, and aircraft data source capabilities) of the FOQA Program. Users have found that existing staff can operate a FOQA Program for up to 20 aircraft. Experience has demonstrated that one additional person is needed for each 20 additional aircraft and a dedicated ground station, operated by specialists, is required for more than 20 aircraft.

31. **OUTSIDE SERVICE OPTIONS:** Some users may contract for data analysis services because of limited resources, program scope, or various other reasons.

## SECTION 6 PROGRAM DESIGN

An operator's objectives must be considered when designing a FOQA Program. These objectives lead to decisions in formulating design specifications, selection of equipment, and developing processes.

32. **TOTAL SYSTEM DEVELOPMENT:** Management decisions regarding the fundamental size, scope, and operation of the program must to be discussed early in the design process. Operators should realize that the second-level systems are developed from the preliminary design decisions. Considerations for total-system development include:

- Fleet Analysis -- Requires identification of aircraft type, aircraft retention periods, current and future restraints on FOQA applications, and required fleet coverage.
- FOQA Reporting Needs -- Requires identification of desired reports and content, the definition of events, and parameters to be measured, recorded, processed, and analyzed. This process will lead to identification of equipment needs for both airborne and ground systems.
- Required Recording Devices -- Requires definition of recording level technology required on each aircraft to achieve FOQA objectives.
- Other Recorder Systems and Reporting Needs -- If other data systems, such as ACMS, maintenance, engine, and ACARS systems are in use or contemplated, they should be evaluated as FOQA data sources and, if appropriate, included in an integrated data processing plan.
- Data Retrieval Methods -- Includes identification of data removal and transmission (to ground station) procedures.
- On-board vs. Ground Data Processing -- Raw data may be processed entirely by a ground station or processed on-board the aircraft using complex equipment. The added on-board complexity offers some attractive benefits such as data compression (storage capacity), reduced time to identify problems, retrieval process simplification, and flexibility in program modifications.

- Centralized vs. Multiple Ground Stations -- Concentration of all data processing within one department (e.g., maintenance) tends to drive the FOQA analytical procedure into a large centralized facility.
  In these cases, the requirement for a limited access facility near flight operations management and safety organizations should also be considered. Other programs permit widely separated hub locations where each has access to the FOQA data. These are usually PC-based systems, particularly if they are combined with on-board processing and simplified reporting/display requirements.
- Management of Data Processing Function(s) -- FOQA data may be processed with data required by other applications. In this case, processing is usually assigned to the maintenance organization. FOQA data may also be separated (either in the retrieval process or after initial reduction) and sent to a FOQA dedicated facility for processing completion. In this case, processing is usually assigned to flight operations or the safety organization.
- Software and Software Changes -- Software applications can be purchased off-the-shelf, contracted for development, or produced internally. If the airline has the capability, it should consider in-house software development. This will ease interpretation of results and permit changes to the on-board and ground station software quickly and at a reduced cost. Smaller airlines will probably elect to purchase most of their software.
  *Note*: All software applications should have an in-house capability to amend exceedance limits.
- Costs -- The airborne system can be implemented with the addition of a QAR and a PC-based ground station at reasonable cost. If measurements must be added beyond those provided by the ECAA-mandated DFDR, developing a FOQA system for the earlier generation aircraft could increase costs substantially. Conversely, acquisition of newer aircraft with engine or ACMS data capability adds little to the additional cost of a FOQA system.

33. **AIRBORNE SYSTEM DEVELOPMENT:** Airborne systems must be compatible with the total system. These systems depend on the type of aircraft, the operations manual for the aircraft, and the operator’s flight operations policies and procedures. The following criteria must be considered during development of the airborne system:

- Event Categories -- Selected to meet reporting requirements.
- Parameters -- Measurements that will support the analysis algorithms for each event category. Frequency of recording must be established for each parameter.
- Exceedance Limits -- Must be set for each event category.
- Data Format -- Must be identified.
- Recording Capacity -- Flight data capacity requirements and flight intervals between downloads must be determined.
- Recording Medium -- Choices include magnetic tape, optical disk, and solid-state memory.
- Data Compression -- Continuous or intermittent depending upon on-board or ground processing.
- On-Board Software Changes --A means for altering and loading the software must be selected.
- Data Quality -- Procedures to protect the quality of the data must be determined, including frequency of calibrations and self-check methods.
- On-board Hardware and Software -- Requirements must be selected.
- Ground Support Equipment -- Requirements for maintenance and troubleshooting must be established.

34. **GROUND SYSTEM DEVELOPMENT:** The ground system must also be compatible with the total system. The following criteria must be considered during ground system development:

- Airborne System Compatibility -- Must be maintained, particularly in data format, exceedance event and parameter selection, recording medium, on-board software development/change, and the hardware chosen for data acquisition and management. If a DMU is included, as part of the on-board hardware, the ground system will usually prepare the input data.
- Flight Record Processing Capacity -- The amount and type of flight data to be processed in the start-up and mature program will affect the selection of ground system hardware. Additional consideration must be given during hardware selection if the ground system will use non-FOQA data.
- Transcription Software -- Converts raw recorded data into engineering units.
- Analysis Software -- Runs the various analysis routines that produce the required reports, such as exceedance event time histories (either tabulated or plotted), trend data, and management reports.
- Video Displays -- Includes the monitors and software necessary for the data processing and analysis functions and special displays, such as, data plots, flight path graphics and cockpit display simulations. The latter displays are particularly important if access to the FOQA data is provided routinely to cockpit crews.

35. **OPERATING PROCESSES:** Required functions should be initially defined for the airborne/ground systems, and then assigned to an organization or individual. Following these actions, a functional diagram should be prepared to include the following flows:

- Data Retrieval Flow -- Responsibility and procedures for removal, transmission, and storage of FOQA data and storage devices.
- Data Reduction Flow -- Responsibility and procedures for data flow through the reduction process, including the transmission and storage of data following the reduction process.
- Data Analysis Flow -- Responsibility and procedures for FOQA data analysis. If the reduction and analysis functions are performed at the same location and by the same organization, the two processes may be developed jointly.
- Report Action Flow -- Responsibility and procedures for report preparation, dissemination, analysis, and report-generated actions, including frequency and agendas for committee meetings.
- Management Action and Follow-Up Flow -- Developed either as a separate process or as part of the report action flow to assign responsibility for actions initiated by the internal organizations receiving the reports.
- Data Storage Flow -- Responsibility and procedures for data retention, including storage facilities, storage media, retention periods, and protection of data from unauthorized access.

36. **PROTECTION PROCESSES:** Established to protect airline management and flight crews from legal action when infractions of ECARs or operational policies and procedures are discovered through the FOQA Program. These processes also protect flight crews from punitive actions by airline management and both, airlines and crews, from punitive actions by the ECAA.
***Note*: The ECAA has stated that it will not use FOQA data for certificate or disciplinary action except in egregious cases that have occurred due to gross negligence or where there has been a willful disregard for safety or the ECARs.**

Protective procedures should be designed with the following components:

- Airline Management/Prior Agreements -- Aimed at defining party roles in the operation of a FOQA Program.
- Confidentiality -- Ensures that airline or crew names are not associated with any FOQA data except through rigid controls employing a minimal number of reputable individuals.
- Anonymity -- Ensures that any identification of flight number and/or flight crews with specific FOQA flight data, necessary during an analysis, is

eliminated permanently, at the earliest possible time, and in accordance with any applicable airline/pilot agreement.

- Crew Contact -- Defines the appropriate conditions for contact with a specific flight crew or individual crewmember following an exceedance event. Appropriate use of information derived from this contact is also defined.
- Data Access and Control -- Includes procedures to identify data requiring protection and assignment of overall responsibility for data protection.
- Record Retention and/or Destruction -- Defines the safeguards during the data retention period and the responsibility for data destruction.

## CHAPTER 3 *FOQA IMPLEMENTATION CONSIDERATIONS*

This chapter describes four phases of recommended procedures for implementation of a FOQA Program.

Phase I -- Includes overall planning to implement the total program and detailed preparation for Phases II and III.

Phase II -- A brief trial demonstration and evaluation testing the system designed in Phase I, evaluating all operational aspects, on one or more aircraft, and developing the operating/protective processes.

Phase III -- A flight operations evaluation that adds more aircraft of the same type to the program until a database, sufficient for program validation, is accumulated.

Phase IV -- Begins when the degree of expertise will support a continuing program in all technical and management respects. It should begin with the aircraft tested in Phase II and III and will expand to add the aircraft numbers and types determined by the program plan. As each new type of aircraft is introduced, it will likely be necessary to employ a Phase II/Phase III type entry period for the evaluation of technical variations.

### SECTION 1 PHASE I --- PREPARATION

Airline management must approve development of a FOQA Program or definitive planning during Phase I. The system design drivers should be identified and developed as discussed in Chapter 2, Section 6. This phase must define the desired product and develop plans for the subsequent phases. The plan will be a living document requiring periodic updating. Management approval should occur before equipment purchases are committed and again before starting Phase II.

37. **IMPLEMENTATION SCHEDULE, PRIORITIES AND ORGANIZATION:** These elements should be developed for the entire program. Airline departments that will be involved in the program, or those that will be data users should be identified and a special implementation organization established.

Representation should involve flight safety, training, flight standards, engineering/maintenance, and the pilots' association. One or more employees, who understand the operator's present data systems, should also be assigned to the group. The organization should function as a steering committee with support personnel assigned for specialized tasks. Initially, this group will define system drivers, operating processes, and protection processes. Additionally, it will determine the FOQA budget and, as implementation proceeds, the organization will become responsible for long-term operation.

38. **SYSTEM HARDWARE, SOFTWARE AND PROCESS DEVELOPMENT:** Should be tailored specifically for Phase II demonstrations and should also support the

elements of the mature system. Equipment and software for the airborne and ground systems are specified and acquired in quantities necessary to support the program through Phase III. Operating processes necessary for Phase I and II must be completed. Protection process development should begin, but completion is not required until the end of Phase II.

39. **EQUIPMENT INSTALLATION AND CHECKOUT:** Installation of airborne and ground systems will require the assistance of hardware and software suppliers.

ECAA certification of the airborne equipment must be planned and accomplished after the first flight of the modified aircraft. When the ground station is operable, testing of analysis software can begin, although the airborne system may require additional work.

40. **ANALYSIS SOFTWARE DEBUGGING:** Debugging and ground trials of the analysis software and operating processes are the final steps in Phase I. The services of the software supplier(s) will again be necessary. Phase I ends with a system readiness evaluation prior to the first data flight.

## SECTION 2 PHASE II -- TRIAL DEMONSTRATION AND EVALUATION

In this phase, management pilots on routine flights operate the aircraft. Data is obtained in a realistic environment to verify the operational aspects of the airborne and ground systems together with the operating processes. This small-scale evaluation confirms that the system is ready for operation and expansion. Operational and protection processes will have been tested and completed. Agreements between management and labor organizations will have been finalized.

41**. DATA QUALITY ASSURANCE:** This is the first task of Phase II. It must be determined that accurate/valid data is recorded in-flight and processed by the ground system in acceptable formats.

42. **EVENT ENVELOPE REVIEW AND REVISION:** Ensures that algorithms for each event category are functional and that the exceedance levels have been properly set to capture desired events without producing large volumes of inconsequential data. This requires careful review by the operations personnel responsible for setting the limitations. This task continues through Phase III to ensure that the fully operational system will have little need for further change.

43. **SOFTWARE EVALUATION AND MODIFICATION:** Identifies and corrects problems in the airborne and ground systems software. Close cooperation among the designers of the software and the ground system operators is vital.

44. **PROCEDURAL VALIDATION:** Reviews and refines:
- The operational management of the program;
- Data protection procedures; and
- Data protection processes.

Completion of this step and an overall readiness review will lead to Phase III.

## SECTION 3 PHASE III - FLIGHT OPERATIONS EVALUATION

This phase generates sufficient data, under realistic conditions, to reveal latent problems not found in prior testing. Corrections made during Phase II will be evaluated. The databases and procedures designed during Phases II and III must be free of errors because a change in any data characteristic will make the before and after change results incompatible. Trend analysis, in particular, will be disrupted.

44. **EVENT ENVELOPE VALIDATION:** A continuation of the Phase II activity, which should continue until optimal event categories, parameters, and limits, have been demonstrated.

46. **TREND DATA BASE INTEGRITY REVIEW:** Occurs when sufficient data has been collected to permit tracking of flight conditions and situations over a period of time. Evaluating the suitability of trend data, in at least two levels of severity, and correction of the data generating processes, are completed during this review.

47. **VALIDATION OF EXCEEDANCE REVIEW AND ACTION PROCEDURES:** Developed in Phase II, these procedures are re-examined to assure that exceedances are properly analyzed and procedures to contact cockpit crews are adequate. Also, remedial action and follow-up processes should be reviewed for satisfactory operation and adherence to prescribed protection rules.

48. **CONFIRMATION OF DATA FEEDBACK PROCEDURES:** Conveys FOQA results to cockpit crews and confirms improvements have occurred. If not properly implemented, management's exposure to potential liability may be increased.

## SECTION 4 PHASE IV -- FOQA PROGRAM OPERATION

A prerequisite for this phase is management's approval of the program following a comprehensive readiness review. Additional commitments of company resources might be required to implement the operator’s total FOQA Program. The decision should be based on satisfactory results obtained during Phase II and Phase III.

A mature program will have four primary functions:

- Data collection;
- Data analysis and review;
- Data trends; and
- Data feedback and resultant action.

# CHAPTER 4 *PLANNING FOR ECAA PARTICIPATION*

49. **REVIEW OF PROGRAM POLICIES AND PROCEDURES:** A review of the FOQA Program’s policies and procedures should be accomplished after implementation is complete. Additionally, the operator should provide periodic updates to the ECAA during FOQA Program development.

50. **DATA TRENDS AND PROGRAM OPERATION FEEDBACK:** Periodic review of trends and lessons learned from the FOQA Program will help the airline and ECAA inspectors decide where to concentrate safety efforts. Information used in these reviews should be de-identified according to company procedures. The focus should be on trends rather than specific flight data and exceedances. The ECAA Inspector should be considered a resource to help coordinate the FOQA Program with other ECAA programs, such as Air Traffic Services, airports, engineering, and maintenance.

# APPENDIX 1
# FOQA Development Plan

The following material provides information that that will assist operators with the development of a FOQA Program. This information may be modified to meet individual requirements.

## 1. GENERAL

The primary system components utilized in FOQA Programs are:
Airborne Data-Recording Equipment---Acquires and captures the necessary in-flight information; and
Ground-Based Analysis Stations---Processes the digital flight recorder data. Ground systems are used to transform exceedance information into the appropriate format for analysis, and generate various reports and visualizations to assist with interpreting exceedances.

The ground-based analysis stations produce information on any detected exceedances that represent deviations from normal operating envelopes or exceptional conditions. The flight data analysis component of the ground-based station categorizes operational events to be flagged by defining a set of parameters that indicate normal operating envelopes.

There are two categories describing special events where parameters deviate from established thresholds:

- Alerts---Indicate serious deviations; and
- Detects---Indicate minor deviations.

Any flight that has been flagged for further consideration is first screened to validate the quality and integrity of the collected data and to filter-out any marginal or transitory irregularities. After this validation step, the remaining special events are analyzed to determine if subsequent processing should include trend analysis or additional action, e.g., immediate notification of engineering or maintenance personnel if any potential damage to the aircraft was identified; reviews to identify corrective measures; and/or crew feedback. Data analysts manually perform this processing to determine if a significant event has occurred. Reports are generated that provide information on the nature of the identified event, categorization of event parameters, and pertinent flight information. A variety of tools are provided by the various ground-based systems for the interpretation and visualization of identified special events, including plots of flight profiles and event parameters.

At the conclusion of the process, the data can be retained based upon airline-established categorization. Normal flights are typically archived and those identified as alert or detect events are stored in historical databases. The ground-based stations also include the capability to apply the appropriate protective procedures, such as de-identification of pilot and specific flight information, to prevent misuse of data and/or reports. A ground-based system may be programmed to include trend analysis capabilities that use historical databases to identify prior similar deviations. This information is useful for determining patterns that may require further exploration.

The parameters for detecting exceedances are based upon those provided by the data capturing, recording, and storage capabilities of the DFDR. The associated thresholds for these parameters vary by the type of aircraft, standard operating procedures, phase of flight, and duration of the event. For example, the threshold of selected parameters may be defined for various altitudes, e.g., 1,000, 500, 250, and 100 feet, during landing mode events. Additional information used in the analysis includes general parameters about the aircraft type and historical information used for trend analysis.

Currently, about 40 to 50 event categories are typically defined based on a strategy of identifying those that would have the greatest potential for safety and performance considerations. Approximately 30 to 40 parameters are assessed for these events during various phases of flight. The event categories and associated parameters have evolved in a trial and error process using empirical flight data and are subject to continual evaluation and modification.

## FOQA PROGRAM GOALS AND OBJECTIVES

➢ **Define the FOQA Program Goals and Objectives**

The following objectives are applicable to all FOQA Programs:

- Collect operational flight data to identify needed improvements in training programs, the ATS system, aircraft/airport design, and evaluation/improvement of flight crew performance;
- Compare the collected data with established procedures and standards to identify needed improvements and develop exceedance information;
- Perform trend analyses of exceedances to evaluate corrective actions and measure performance over time; and,
- Use analyzed data in formal awareness and feedback programs to enhance safety in the following areas:
  - ♦ In-flight procedures;
  - ♦ Flight training procedures;
  - ♦ Crew performance during all phases of flight;
  - ♦ Air Traffic Services procedures;
  - ♦ Cockpit crew/aircraft systems interface; and
  - ♦ Aircraft and airport design/maintenance.

➢ **Summarize Program Protective Provisions That Will Ensure Acceptance By All Participants, Including Pilot Associations**.

## 3. FOQA PROGRAM ELEMENTS

➢ **Describe the Following Specific FOQA Program Elements**

**Airborne System**

Describe the airborne system configuration and indicate the equipment to be installed in the aircraft. Discuss maintenance policies for the airborne system.

**Ground System**

Describe the ground-based system including hardware and software.

**Other Equipment**
Describe any other FOQA components such as downlink of data from aircraft to ground stations; trend analysis software, etc.

**Organization**
Describe the supporting organization and management.
Indicate the duties and responsibilities of associated personnel for administration; data collection and retrieval; data security and protection; data reduction and analysis; assessment of exceedances and trends; corrective actions and feedback; data trends; record retention, etc.

Describe committees/teams tasked for such activities as technical advice; monitoring and evaluation of the program and data; liaison with pilot associations; and event reviews.

**FOQA Program**
Describe the concept of a FOQA Program.

**Data Protection and Security**
Describe the data use agreement with flight crew associations for individual protection and data use.
Describe methods for protecting the data, controlling access, assuring confidentiality and de-identification; crew contact; record retention; and data safeguards.

**Event Classifications and Definitions**
Define the categories/classifications to be used for events. Describe the process for defining and maintaining events of interest and associated parameters.

**Collection and Retrieval**
Describe how data will be recorded (i.e., raw flight data vs. record only exceedance data), the transport of data from aircraft to ground station, and logistics.

**Data Reduction and Analysis**
Describe how the recorded data will be transformed into the desired data quality and integrity standards. Include data classification and verification of events.

**Exceedance Review and Evaluation**
Describe procedures to review and evaluate event reports; reporting needs; notification of appropriate personnel, i.e., cockpit crews, engineering/maintenance departments, training, etc.; resolution of exceedances; determination of corrective actions; feedback loop; and periodic summaries of events.

**Trends and Record Retention**
Describe procedures for maintaining information for trend analysis (including databases), detection of trends, periodic reporting, evaluation of identified trends, corrective actions, and feedback.

**Data Usage**
Describe any additional anticipated usage of FOQA data.

**Glossary**
Define all acronyms used in the program:

- **ACMS** - Aircraft Condition Monitoring System
- **AIDS** - Aircraft Integrated Data System
- **AIMS** - Aircraft Integrated Monitoring System
- **ATS** - Air Traffic Services
- **DFDAU** - Digital Flight Data Acquisition Unit
- **DFDR** - Digital Flight Data Recorder
- **DMU** - Data Management Unit
- **DRU** - Data Recovery Unit

- **FDAU** - Flight Data Acquisition Unit
- **FOQA** - Flight Operations Quality Assurance
- **IEP** - Internal Evaluation Program
- **OQAR** - Optical Quick Access Recorder
- **QAR** - Quick Access Recorder
- **STC** - Supplemental Type Certificate
- **TC** - Type Certificate

## 4. REFERENCES

- Include documentation of reference material utilized during program development.

# APPENDIX 2
# HARDWARE AND SOFTWARE SYSTEMS

**AIRBORNE SYSTEM CONFIGURATIONS:** FOQA Programs use data provided by one of several on-board data management systems. These data management systems were known initially as Aircraft Integrated Data Systems (AIDS). They became known as Aircraft Integrated Monitoring Systems (AIMS) when their capabilities were expanded to include flight operations data and include Aircraft Condition Monitoring Systems (ACMS), Auxiliary Data Acquisition System (ADAS), and Flight Data Acquisition and Management System (FDAMS). AIMS is used in this EAC as a general reference to data management systems.
Although the early AIMS met the basic requirements to record and receive data, they were deficient in two important aspects. First, they were limited in their capability to adapt to changes in data requirements. Second, AIMS had limited on-board processing capability, thus preventing a timely alert of important exceedances. In most basic configurations, the airborne system components interface with the ECAA-mandated DFDR to derive data. Figure 4 illustrates an early configuration.

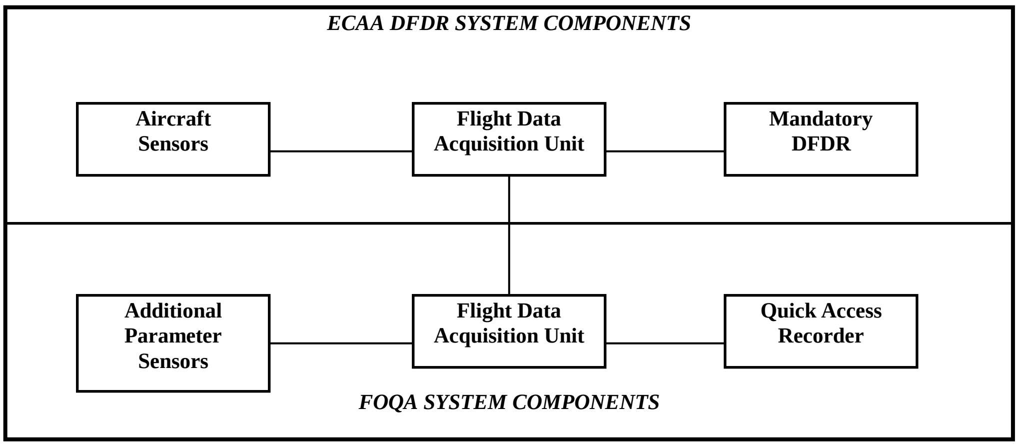



**Figure 4**

## Elementary FOQA Airborne Recording System Configuration

The aircraft sensors in Figure 4 meet the parameters required by the relevant ECAR. The additional sensors provide selected system information to evaluate the particular events chosen for review.

An FDAU acquires and processes the parameter data into a digitized data stream for recording by the DFDR. The second FDAU provides additional capacity and maintains separation (buffering) of FOQA data for QAR storage.

The most common equipment for recording FOQA data is a QAR. This unit contains magnetic tape cartridges or cassettes that can be removed and replaced quickly, and is usually accessible from the cockpit. Early QARs had little, if any, processing capability. The flight-hour capacity of these recorders varies as a function of data rates and data frame formats, but falls short of airline operational requirements, even under the best of circumstances. Newer optical disk QARs provide expanded storage capacity.

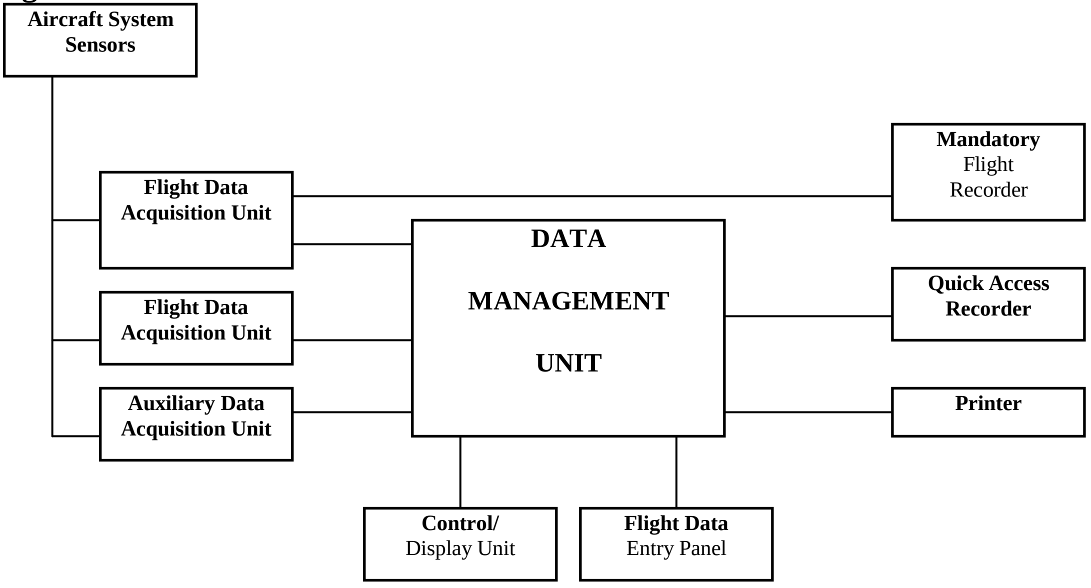
Airborne configurations fall into two categories, based on the applicable ARINC data system design specification:
1) ARINC Characteristic 573, Aircraft Integrated Monitoring Systems, and
2) ARINC Characteristic 717, Flight Data Acquisition and Recording System.

## ARINC 573 AIMS CONFIGURATIONS

This FDAU specification is applicable to first-generation DFDRs installed on the L-1011, DC-10, A-300, B-737, and early B-747 aircraft. For this generation of aircraft, the aircraft sensor signals are usually analog and require considerable signal processing by the FDAU. The selected flight data parameters are generally hard-wired to the FDAU and aircraft downtime is required to reconfigure data input requirements.

### Aircraft Integrated Monitoring System Configuration (ARINC 573 SYSTEM)

**Figure 5**



The DMU component processes and stores selected exceedance reports but performs limited real-time data analysis. The unit may be programmed to perform multiple functions, such as increasing the data rate to the QAR. Independent processors and signal conditioning permit processing the mandatory data, including aircraft system and operational data.

The cockpit Flight Data Entry Panel (FDEP) is used by the cockpit crew to enter pertinent flight information, such as aircraft number, trip number, date, time, and gross weight. There is also an event button to mark occurrences that the crew may want analyzed following the flight.

The Control and Display Unit (CDU) serves as an input and output device to allow a ground operator to program the DMU options for report generation, recovery of flight-generated reports, and other maintenance information. The printer provides routine maintenance and engineering reports, flight data reports, and system troubleshooting queries.

The Auxiliary Data Acquisition Unit (ADAU) is a low-capacity FDAU capable of processing special or unusual data signals.

## ARINC 717 AIMS CONFIGURATIONS

Because of the dramatic increase in parameters and capabilities, these are considered second-generation data management systems. The major changes in aircraft design, including glass cockpits, greatly influenced and enhanced the AIMS concept. Avionics systems and subsystems manufacturers expanded digital data interfaces to communicate with each other and aircraft data systems according to the ARINC 429 Digital Information Transfer Standard (DITS). These digital data buses provide ready access to multiple system parameters that reflect the operation of the aircraft, engines, and their associated systems.

This FDAU specification applies to B-757, B-767, MD11, MD80, A-320, A-330, A-340, later model B-747 and B-737 aircraft, and others. Figure 6 illustrates a typical ARINC 717 AIMS configuration.

## Aircraft Flight Data Acquisition and Recording System (ARINC 717 System)

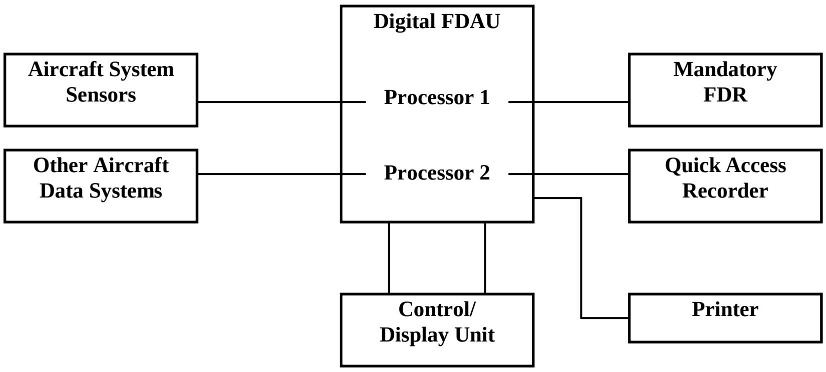



**Figure 6**

Except for the FDAU, the system components in this configuration are similar to those of earlier generations. A Digital FDAU (DFDAU), which still acquires data from the aircraft's digital data buses, has superseded the FDAU and conversion-processing requirements have been reduced substantially. This allows the DFDAU to handle all the functions previously accomplished by the FDAU and DMU. Dual independent processors, contained within a single unit, maintain separation of the ECAA-required DFDR data and voluntary FOQA data. Microprocessor architecture provides some capability to detect, analyze, and report pre-established events. When provided with the required parameters, microprocessors also can be programmed to recognize specific phases of flight, generate reports, and control the QAR.

The QAR flight-hour capacity problems were increased by the additional data provided by the DFDAU. Output data rate to the QAR doubled from the standard 64 words per second to 128 words per second. Users welcomed the improved data rate, however, it increased the frequency of cassette removals.

Parameters, exceedance reports, and other logic modifications for the earlier DFDAUs frequently involve reprogramming of Programmable Read Only Memory (PROM) circuit chips. In most cases, the manufacturer must accomplish this because specialized equipment is required

The Control and Display Unit (CDU) displays/prints maintenance or exceedance reports. Limited report format and event process changes also may be accomplished. These report the status and values of user-selected parameters for specific phases of flight. Typically, reports are generated for takeoff, climb, cruise, descent, and approach and landing.

## CURRENT PRODUCTIONS SYSTEMS -- ARINC 717 AIMS

State-of-the-art AIMS are referenced by different acronyms and labels depending on the specific manufacturer or aircraft type. For example, the Boeing 747-400 system is called an Aircraft Information Management System (AIMS). The McDonnell Douglas MD-11 system is called an Auxiliary Data Acquisition System (ADAS) and that of the Airbus-330/A-340 is called an Aircraft Recording and Monitoring System (ARMS). Another manufacturer has selected the term Flight Data Acquisition and Management System (FDAMS).

Current AIMS far surpass the capabilities of the earlier configurations. The newer designs are functionally similar, but manufacturers' approaches to user-oriented options vary considerably. Capability has expanded because the advanced design now allows most of the individual aircraft systems to interface in the common language of the ARINC 429 Digital Information Transfer Standard (DITS). Continued advances in computer memory capacity, processors, and system designs also have contributed to the improvement of earlier ARINC 717 AIMS.

These new designs (Figure 7) optimize the relationships and efficiencies of multiple systems that cross-utilize information from a number of other systems to control their own operational modes and responses. These interfaces have always been necessary, but the required information was not generally available from a centralized source and, in many cases, was generated redundantly. The DITS concept has grown and many of these systems now are identified as data management systems and interface through their digital data buses with the aircraft. Among the more familiar systems are the Flight Management Computer (FMC), ACARS, Fuel-Quantity Indicator (FQI), Air-Data Computer (ADC), and Engine Indication and Crew-Alerting System (EICAS).

The number of DITS data buses for a particular aircraft depends on the systems installed, but typically range from 40-50 and can provide 3,000-4,000 parameters for AIMS. The AIMS do not use all the parameters available at any given time. The FOQA Programs use a subset of the AIMS selections.

The DMU performs all of the functions previously described and provides additional advanced on-board processing and expanded operator programming flexibility, however, acquiring, analyzing and sorting of aircraft systems information and distributing of the results to user-selected devices remain primary functions. The unit acquires selected parameters from the multiple data sources, evaluates the data based on user-defined requirements, detects predefined event conditions, and stores the selected event information within the DMU or QAR (or transmits it to the ground via ACARS). The information may be recorded in American Standard Code for Information Interchange (ASCII) format for direct generation of post-flight reports or as raw flight data records. The DMU allows real-time retrieval of selected data on the cockpit printer or post-flight retrieval through the MCDU.

**State-of-the-Art AIMS System Configuration**

A user first selects the operational events and the associated parameters to be monitored. These requirements are programmed on a ground data processing station, using software provided by the system supplier, and stored on a floppy disk. The floppy disk information is programmed onto the DMU disk drive. The floppy may be used to upload software modifications to the DMU or to download flight reports stored in the solid-state memory. These reports provide information on multiple parameters relevant to the event recorded.

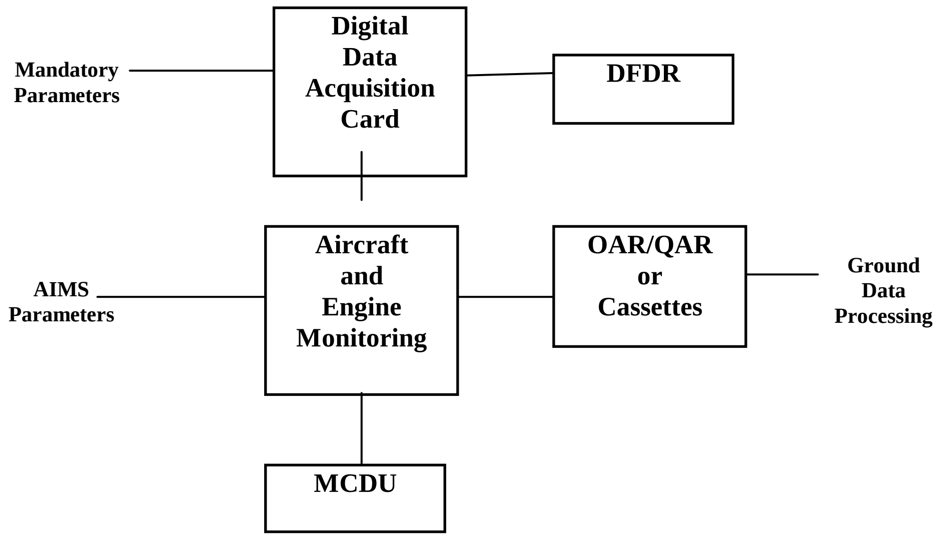



**Figure 7**