SLCAP 4220

CIVIL AVIATION AUTHORITY OF SRI LANKA

FLIGHT DATA ANALYSIS PROGRAMME

A GUIDE TO GOOD PRACTICE

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FLIGHT DATA ANALYSIS PROGRAMME

A GUIDE TO GOOD PRACTICE

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FOREWORD

This document outlines good practice relating to first establishing and then obtaining worthwhile safety benefits from an Operator's Flight Data Analysis (FDA) programme which shall eventually be a proactive and on-punitive programme for gathering and analysing data recorded during routine flights to improve Flight Crew Performance, Operating Procedures, Flight Frequency and Air Traffic Control procedures, Air Navigation Services or Aircraft Maintenance and Design. Such a programme should logically complement the Incident Reporting System and to Line Operational Safety Audit, (LOSA) programme. Standard contained in ICAO Annex 6 Part 1 Chapter 3 which is locally implemented in terms of ASN 039 requires an operator who operates aircraft of a maximum certificated Take off Mass in excess of 27 000 Kg to establish and maintain a Flight Data Analysis Programmeand part of its Accident Prevention and Flight Safety programme.

The guidelines given in the documents will help an operator to conform to this aforesaid requirements in a systematic and meaningful manner.

It will be regularly reviewed and revised by CAA and the Industry to reflect the wider use of FDA and developing technologies and methodologies. Procedures contained in this Manual may be amended due to either change in the applicable requirements or the need for improvements of quality and effectiveness of procedures.

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ABBREVIATIONS

ACARS	Aircraft Communication Addressing Reporting System
ADS	Air Data System - computer interface between aircraft systems and instrumentation/FDR
AGL	Above Ground Level - measured by aircraft's radio altimeter
APMS	Aviation Performance Measuring System - NASA's advanced FDR analysis tool set
AQP	Advanced Qualification Programme – relates training to operational experience
ASR	Air Safety Report - (normally) aircrew report on a safety incident
ALPA	Airline Pilots Association
CAADRP	Civil Airworthiness Data Recording Programme
C of A	Certificate of Airworthiness
DFDR	Digital Flight Data Recorder - normally the crash recorder
EFIS	Electronic Flight Instrument System
EGT	Exhaust Gas Temperature
FDR	Flight Data Recorder - normally the crash recorder
FLIDRAS	Teledyne FDA analysis software
FMC	Flight Management Computer - aircraft system control computer
FMS	Flight Management System - aircraft control system
FOQA	Flight Operational Quality Assurance - FAA's term for flight data Analysis and it's systematic use as a quality and safety monitor.
FSO	Flight Safety Officer - investigates incident reports and promotes safety
GRAF	Ground Replay and Analysis Facility – Teledyne Controls - Flight Data Company - FDR data replay and analysis software
JAR-145	Joint Aviation Requirements - European Airworthiness/ Engineering codes
JAR-OPS	Joint Aviation Requirements - Flight Operations codes
MEL	Minimum Equipment List

MORS	Mandatory Occurrence Reporting Scheme
OQAR	Optical Quick Access Recorder
PCMCIA	Personal Computer Miniature Computer Interface Adaptor – credit card size PC interfaces - Disk storage versions used for QAR recording mediums
QA	Quality Assurance
QAR	Quick Access Recorder - secondary recorder with a removable recording medium - traditionally tape, now moving towards Optical Disk or solid state
SFB	Specific Fuel Burn
SID	Standard Instrument Departure
SOP	Standard Operating Procedure
SSDFDR	Solid State Digital Flight Data Recorder
TCAS	Traffic Alert and Collision Avoidance System
UFDR	Universal Flight Data Recorder - Sundstrand/Allied Signal crash recorder
UNS	User Needs Study - Research study into the application of FDR data within an operator

DEFINITIONS

Accident	An unintended event or sequence of events that cause death injury, environmental or material damage.
FDA Event/ Exceedance	Circumstances detected by an algorithm looking at FDR data
FDA Parameter	Analysis Measurements taken from every flight e.g. maximum g at landing.
Hazard	A physical situation, often following from some initiating event that can lead to an accident.
Incident	An occurrence, other than an accident, associated with the operation of an aircraft that affects or could affect the safety of operation.
Level of Safety	A level of how far safety is to be pursued in a given context, assessed with reference to an acceptable risk, based on the current values of society.
Qualitative	Those analytical processes that assess system and aeroplane safety in a subjective, non-numerical manner.
Quantitative	Those analytical processes that apply mathematical methods to assess system and aeroplane safety.
Risk	Is the combination of the probability, or frequency of occurrence of a defined hazard and the magnitude of the consequences of the occurrence.
Risk Assessment	Assessment of the system or component to establish that the achieved risk level is lower than or equal to the tolerable risk level.
Safety Assessment	A systematic, comprehensive evaluation of an implemented system to show that the safety requirements are met.
Safety Objective	A safety objective is a planned and considered goal that has been set by a design or project authority.
Safety Policy	Defines the fundamental approach to managing safety and that is to be adopted within an organization and its commitment to achieving safety.
Severity	The potential consequences of a hazard.
System	A combination of physical components, procedures and human resources organized to achieve a function.
Validation	The process of determining that the requirements are the correct requirements and that they are complete.
Verification	The evaluation of the results of a process to ensure correctness and consistency with respect to the inputs and standards provided to that process.

USEFUL REFERENCE MATERIAL

NOTE: *Many of these documents are periodically revised. Please ensure you refer to the latest version.*

- Annex 6 Part 1 Amendment 26. Flight Data Analysis. ICAO (Latest Amendment 29)
- CAAP 42L-4(0): Flight Recorder Maintenance. CASA Australia
- CAP 382. The Mandatory Occurrence Reporting Scheme. UK CAA
- CAP 360 Part 1. Air Operator's Certificate - Operation of Aircraft. UK CAA
- CAP 712 Safety Management Systems for Commercial Air Transport Operations. UK CAA Second edition, 2 April 2002
- CAP 731 Approval, Operational Serviceability and Readout of Flight Data Recorder Systems. UK CAA 1st edition 2003
- DO160. Environmental Conditions and Test Procedures for Airborne Equipment. RTCA
- Doc 9422. Accident Prevention Manual. ICAO/ Accident Prevention Programme Manual (Ed 2005)
- ED-14 Environmental Conditions and Test Procedures for Airborne Equipment. EUROCAE
- ED-55 Minimum Operational Specifications for Flight Data Recorder Systems. EUROCAE
- ED-112 Minimum Operational Performance Specification For Crash Protected Airborne Recorder Systems
- JAR–OPS 1.160. Preservation, Production and Use of Flight Recorder Recordings. JAA
- JAR-OPS 1.037. Accident Prevention and Flight Safety Programmes. JAA
- MMEL Global Temporary Revision TR-G5. UK CAA
- Specification 10A: Flight Data Recorder for Aero plane Accidents Investigation. UK CAA
- UK Air Navigation Order 2000, Article 117. Mandatory Occurrence Reporting.

Chapter 1 Flight Data Analysis

For the purpose of this Manual, a Flight Data Analysis (FDA) Programme may be defined as:

A proactive and non-punitive programme for gathering and analyzing data recorded during routine flights to improve flight crew performance, operating procedures, flight training, air traffic control procedures, Air Navigation Services, or aircraft maintenance and design.

1.1. Introduction

Flight Data Analysis (FDA) programmes, sometimes referred to as Flight Data Monitoring (FDM), or Flight Data Operations Quality Assurance (FOQA), provide another tool for the proactive identification of hazards. They are a logical complement to the incident reporting systems and to line operations Safety Audit (LOSA) programmes.

Flight Data Analysis (FDA) programmes assists an operator to identify, quantify, assess and address operational risks. FDA can be actively used to support a range of Airworthiness and Operational Safety tasks. Through this co-operative development work many farsighted operators have demonstrated the safety benefits of FDA such that the International Civil Aviation Organization (ICAO) recognizing the potential for accident prevention, introduced provisions for a Flight Data Analysis Programme to be part of an Operator's accident prevention and Flight Safety Programme. Operators of larger aircraft authorized to conduct International Commercial Air Transport Operations will be accountable for the operation of a non-punitive FDA Programme, which contains adequate safeguards to protect the source(s) of the data. Operators may obtain the services of a specialist contractor to operate the programme.

ICAO REQUIREMENT

From 1 January 2005, an operator of an aeroplane of a maximum certificated take-off mass in excess of 27000 kg shall establish and maintain a Flight Data Analysis Programme as part of its Accident Prevention and Flight Safety Programme

In compliance with para 3.2.3 of Annex 6 Part 1 , All contracting States require the establishment and maintenance of an Accident Prevention and Flight Safety Programme (AP&FSP) and include the requirement for FDA. The content of safety programmes, including FDA, will need to be confirmed as acceptable by the Civil Aviation Authority of Sri Lanka's Flight Operations Inspectors.

It is recognized that there is a wide range of operators covered by these requirements and that there is no "one size fits all" system. The size and age of aircraft may determine the parameters available for analysis. The programme effectiveness and efficiency of a small fleet or operation may be helped by pooling analysis within a group of similar operations. While retaining responsibility for risk assessment and action, some operators may wish to contract out the basic analysis due to lack of expertise or resources.

As an aid to operators, **Appendix C** provides a checklist of guiding principles that highlight some of the fundamental concepts that should be considered when putting one of these pro-active safety processes in place.

In a similar manner to the ICAO Accident Prevention Manual (Ed 2005), this Document outlines good practice and indicates what may constitute an Operator's FDA programme system that is acceptable to the CAASL. It is intended to be regularly reviewed and revised by CAASL in consultation with Industry as widespread FDA experience develops.

1.1.1. Document Structure

This document includes the following elements:

Chapter 2: Objectives of an operator's FDA Programme
Chapter 3: Description of a Typical FDA Programme
Chapter 4: FDA Programme within a Safety Management System.
Chapter 5: Planning the Introduction of FDA Programme.
Chapter 6: Organization and Control of FDA Information.
Chapter 7: Interpretation and Use of FDA Information.
Chapter 8: Legislation and Requirements related to FDA.
Chapter 9: Legislation Related to FDA Information.
Chapter 10: Mandatory Occurrence Reporting and FDA.
Chapter 11: Maintaining Aircraft FDA systems

1.1.2. Purpose of this Document

This document is designed to meet the following objectives:

- Give guidance on the policy, preparation and introduction of FDA within an Operator.
- Outline CAASL's view on how FDA may be embodied within an Operator's Safety Management System.
- Describe the principles that should underpin a FDA system acceptable to the CAASL.

1.1.3. Comments on this Document

This document has been adapted from the COSCAP –SA document as "Flight Data Analysis Programme – A Guide to Good practice "which is based on ICAO Accident Prevention Manual (Edition 2005) and the CAA UK CAP 739. The users are invited to send the comments on this document to the CAASL.

Chapter 2 Objectives of an Operator's FDA System

An FDA Programme allows an operator to compare their Standard Operating Procedures (SOPs) with those actually achieved in everyday line flights.

A feedback loop, preferably part of a Safety Management System (SMS), will allow timely corrective action to be taken where safety may be compromised by significant deviation from SOPs.

The FDA system should be constructed so as to:

2.1. Identify areas of operational risk and quantify current safety margins.

Initially an FDA system will be used as part of an operator's System Safety Assessment to identify deviations from SOPs or areas of risk and measure current safety margins. This will establish a baseline operational measure against which to detect and measure any change.

Example: Current rates of rejected take-offs, hard landings, unstable approaches.

2.2. Identify and quantify changing operational risks by highlighting when non-standard, unusual or unsafe circumstances occur.

In addition to highlighting changes from the baseline, the system should enable the user to determine when non-standard, unusual or basically unsafe circumstances occur in operations.

Example: Increases in above rates, new events, new locations.

2.3. To use the FDA information on the frequency of occurrence, combined with an estimation of the level of severity, to assess the risks and to determine which may become unacceptable if the discovered trend continues.

Information on the frequency of occurrence, along with estimations of the level of risk present, is then used to determine if the individual or fleet risk level is acceptable. Primarily the system should be used to deduce whether there is a trend towards unacceptable risk prior to it reaching risk levels that would indicate the SMS process has failed.

Example: A new procedure has introduced high rates of descent that are approaching the threshold for triggering GPWS warnings. The SMS process should have predicted this.

2.4. To put in place appropriate risk mitigation techniques to provide remedial action once an unacceptable risk, either actually present or predicted by trending, has been identified.

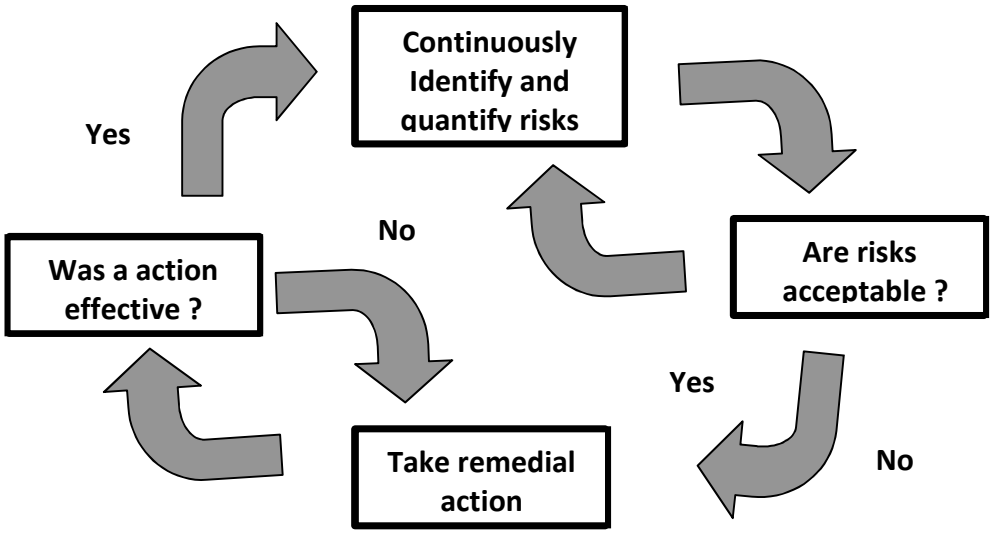
Once an unacceptable risk, either actually present or predicted by trending, has been identified, then appropriate risk mitigation techniques must be used to put in place remedial actions. This should be accomplished while bearing in mind that the risk must not simply be transferred elsewhere in the system.

Example: Having found high rates of descent the Standard Operating Procedures (SOPs) are changed to improve control of the optimum/maximum rates of descent being used.

2.5. Confirm the effectiveness of any remedial action by continued Analysis.

Once a remedial action has been put in place, it is critical that its effectiveness is monitored, confirming that it has both reduced the original identified risk and not transferred the hazard elsewhere.

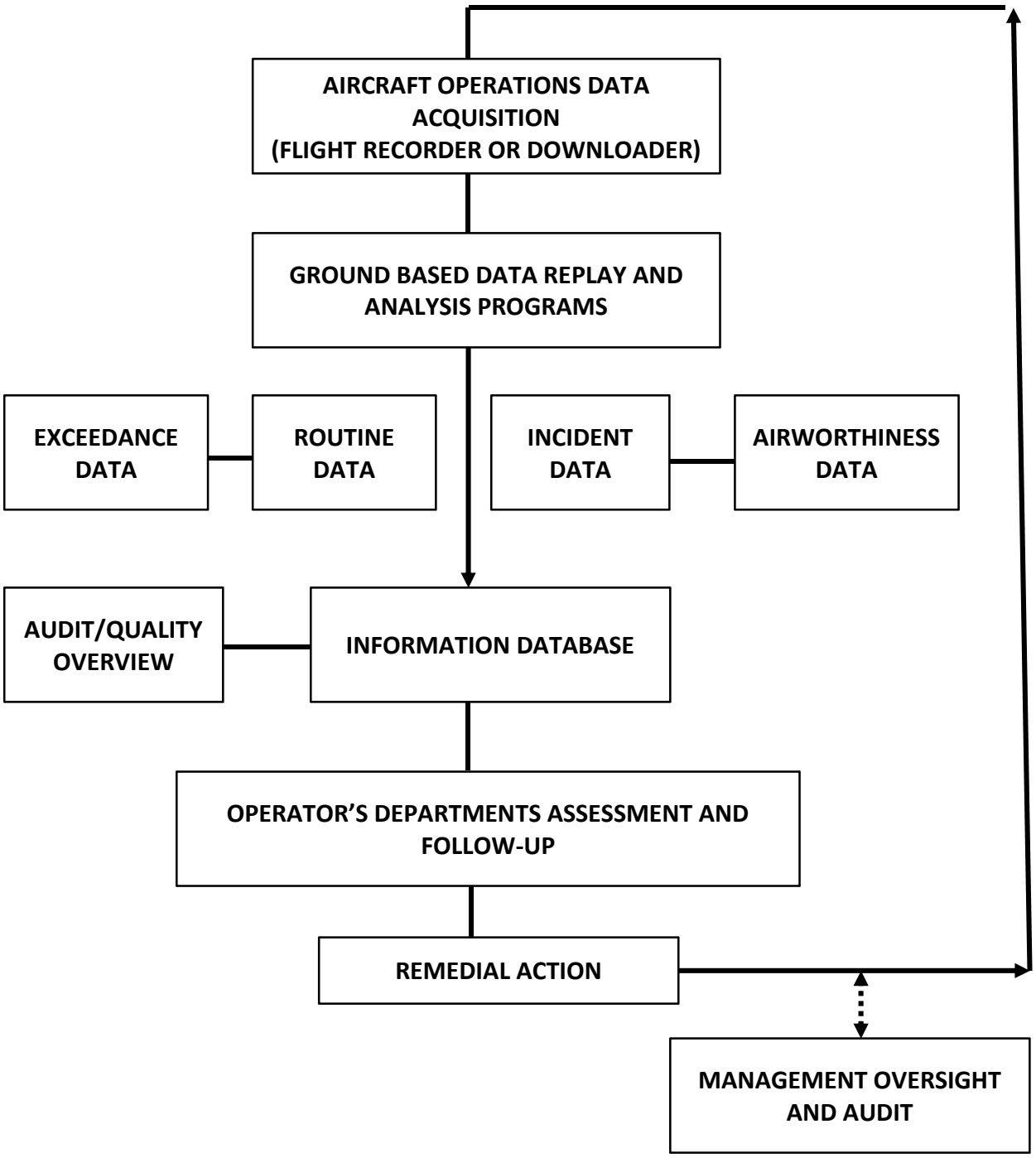
Example: Confirm that the other measures at the airfield with high rates of descent do not change for the worse after changes in approach procedures**.**



Chapter 3 Description of a Typical FDA System

This chapter describes the principal components of a typical FDA system. This is not necessarily an optimum system but one that reflects current practice. Details of other options are shown in subsequent chapters.

3.1. System Outline - Information Flow



3.2. Aircraft Operations - Data Acquisition

Modern glass –cockpit and fly-by-wire aircraft are equipped with the necessary digital data buses from which information can be captured by a recording device for subsequent analysis. Older aircraft may be retrofitted to record additional parameters. However, for older (non-digital) aircraft, it is unlikely to be practical to record sufficient parameters to support a viable FDA Programme.

The number of parameters recorded by the mandatory Flight Data Recorder (FDR) may determine the scope of an FDA programme. Unfortunately, in some cases the number of parameters and recording capacity required by law to be recorded to support accident investigations may be insufficient to support and effective FDA Programme. Thus many operators are opting for additional recording capacity, capable of being easily downloaded for analysis.

Data is obtained from the aircraft's digital systems by a Flight Data Acquisition Unit (FDAU) and routed to the crash protected Digital Flight Data Recorder (DFDR). In addition to this mandatory data "stream", a second output is generated to a non-mandatory recorder. This output is often more comprehensive than that of the crash recorder due to the increased capacity of this recorder. Unlike the DFDR, this recorder has a removable recording medium such as a tape or optical disk cartridge. Because these are easy to gain access to replace the medium, these are known as Quick Access Recorders (QARS).

The QAR tapes/disks are replaced at the end of each day or sometimes after a period of several days have elapsed, dependent on media capacity and data recovery strategy, and sent to a central point for replay and analysis. This normally takes place at the operator's major hub airport for convenience. New technology QARs are capable of supporting more than 2,000 parameters at much higher sampling rates than the FDR. The expanded data frame greatly increases the resolution and accuracy of the output from ground analysis programmes.

As an alternative to the QAR, some operators routinely download information contained on the crash recorder. While this is not practicable with the older, tape based devices; the modern solid-state recorder is reliable and fast.

To eliminate the task of moving the data from the aircraft to the ground station by physically removing the recording medium of the QAR, newer systems automatically download the recorded information via secure wireless systems when the aircraft is in the vicinity of the gate. In still other systems, the recorded data is analyzed on board while the aircraft is airborne. The encrypted data is then transmitted to a ground station using satellite communications. This reduces the logistical problems associated with the movement of media or physical downloading tasks. Chapter 5 paragraph 6 technical specifications gives an outline of some of the current technologies applicable to FDA.

3.3. Ground-Based Data Replay and Analysis Programmes

Data is downloaded from the recording device in to a central replay and analysis department, where the data is held securely to protect this sensitive information. A variety of computer platforms, including networked PCs, are capable of hosting the software needed to reply the recorded data. Replay software is commercially available, however, the computer platform will require front-end interfaces (usually provided by the recorder manufacturers) to cope with the variety of QAR, FDR and other inputs available today.

FDA programmes generate large amounts of data requiring specialized analytical tools. These tools, which are commercially available, facilitate the routine analysis of flight data in order to reveal situations that require corrective action.

The analysis software checks the downloaded flight data for abnormalities. The exceedances detection software typically includes a large number of trigger logic expressions derived from a variety of sources, such as, flight performance curves; standard operating procedures; engine manufactures performance data; airfield layout and approach criteria. Trigger logic expressions may be simple exceedances, such as redline values. However, the majority are composites, which define a certain flight mode, aircraft configuration or payload-related condition. Analysis software can also assign different sets of rules dependent on airport or geography. For examples, noise sensitive airport may use higher than normal glide slopes on approach paths over populated areas.

Events and measurements can be displayed on a ground computer screen in a variety of formats. Recorded flight data is usually shown in the form of color-coded traces and associated engineering units, cockpit simulations of the external view of the aircraft. Aircraft verification and validation procedures are critical at this stage to increase the reliability of output.

Traditionally the data has been processed through analysis programs, retained for a set period of time for air safety report follow-up and then destroyed. However, the retention of the data, or at least a selection of the parameters, for amalgamation into longer-term historical views of operations is now considered to be essential. This may be held in either raw or processed form.

3.4. The Information

a) Typically, FDA data today are being used in five areas.
b) Exceedance detection;
c) Routine measurements;
d) Incident Investigations;
e) Continuing airworthiness; and
f) Linked databases (or integrated safety analysis)

3.4.1. Exceedance Detection

Exceedance or event detection is the traditional approach to FDA that looks for deviations from flight manual limits, standard operating procedures and good airmanship. There is normally a set of core events that cover the main areas of interest that are fairly standard across operators. See Appendix B paragraph 1.

Example: High take-off rotation rate, stall warning, GPWS warning, flap limit speed Exceedence, fast approach, high/low on glide slope, heavy landing.

FDA provides useful information from safety events, which can complement that provided in crew reports.

Example: Reduced flap landing, emergency decent, engine failure, rejected take -off, go-round, TCAS or GPWS warning, system malfunctions, etc.

Companies may also modify the set of core events (in accordance with the agreement with their pilots) to account for unique situations they regularly experience or the SOPs they use.

Example: To avoid nuisance reports from a non-standard SID.

They may also define new events (with the agreement of the pilots) to address specific problem areas.

Example: Restrictions on the use of certain flap settings to increase component life.

Care must be taken that in order to avoid an Exceedance, crew does not attempt to fly the FDA profile rather than follow SOPs. Such an action can quickly turn a poor situation in to something worse.

3.4.2. Routine Data Measurements

Increasingly, data is retained from all flights and not just the significant ones producing events. The reason for this is to monitor the more subtle trends and tendencies before the trigger levels are reached. A Selection of measures are retained that are sufficient to characterize each flight and allow comparative analysis of a wide range of aspects of operational variability. Trends may be identified before there are statistically significant numbers of events. Emerging trends and tendencies are monitored before the trigger levels associated with Exceedance are reached.

Examples of parameters monitored: take-off weight; flap setting; temperature; rotation and take-off speeds vs. scheduled speeds; maximum pitch rate and attitude during rotation; gear and retraction speeds, heights and times.

Examples of analysis: Pitch rates from high vs. low take-off weights; pilot technique during good vs. bad weather approaches; touchdowns on short vs. long runways.

3.4.3. Incident Investigation Data

FDR data should be used as part of the routine follow-up of mandatory occurrences and other technical reports. FDR data has been found to be very useful in adding to the picture painted by the flight crew report, quantifying the impressions gathered from the recollections after the heat of the moment. System status and performance can add further clues to cause and effect.

FDR data obtained for use in this way falls under the mandatory requirements of ICAO and JAR-OPS and hence de-identification of the data, required to maintain FDA confidentiality, does not usually apply. As the crew have already filed reports then this is reasonable in an open, pro-active safety culture that provides constructive feedback.

3.4.4. Examples of Incidents where FDR data could be useful:

a) Emergencies such as
   i) High speed rejected take-offs;
   ii) Flight control problems;
   iii) System failures, etc;

b) High cockpit workload conditions as corroborated by such indicators as :
   i) Late decent;
   ii) Late localizer and/or glide slope interception;
   iii) Large heading change below a specific height;
   iv) Late landing configuration

c) Unsterilized and rushed approaches, glide path excursions, etc;

d) Exceedance of prescribed operating limitations (such as flap limit speeds, engine over-temperatures, V-speeds, stall onset conditions, etc; and

e) Wake vortex encounters, low-level wind shear, turbulence encounters or other vertical accelerations, etc

3.4.5. Continued Airworthiness Investigation Data

Both routine and event data can be utilized to assist the continued airworthiness function. Engine Analysis programs use measures of engine operation to monitor efficiency and predict future performance. These programs are normally supplied by the engine manufacturer and feed their own databases. Operators should consider the potential benefits of including the wider use of this data within their continued airworthiness programmes.

E**xamples of continued airworthiness uses:** Engine thrust levels; airframe drag measurement; avionic and other system performance Analysis; flying control performance; brake and landing gear usage.

3.5. The Information Database

All the information gathered should be kept either in a central database or in linked databases that allow cross-referencing of the various types of data. These links should include air safety and technical fault reporting systems to provide a complete view of the operation. Where there is an obvious tie up between the systems then this should be highlighted by the system.

Example of links: A heavy landing should produce a crew report, a FDR event and also an airworthiness report. The crew report will provide the context, the FDR event the qualitative description and the airworthiness report the result.

The integration of all available sources of safety data provides the company safety management system with viable information on the overall safety health of the operation.

3.6. Operator's Departments - Assessment and Follow-up

Typically, operators follows a closed-loop process in applying an FDA programme, for example:

Baseline stabled. Initially, operators establish a baseline of operational parameters against which changes can be detected and measured.

Example: Rate of unstable approaches, or hard landings

Unusual or unsafe circumstances highlighted. The user determines when nonstandard, unusual or basically unsafe circumstances occur; by comparing them to the baseline margins or safety, the changes can be quantified.

Example: Increases in unstable approaches (or other unsafe events) at particular locations.

Unsafe trends identified. Based on the frequency of occurrence, trends are identified. Combined with an estimation of the level of severity, the risks are assessed to determine which, may become unacceptable if the trend continues.

Example: A new procedure has resulted in high rates of descent that are nearly triggering GPWS warnings.

Risks mitigated: Once an unacceptable risk has been identified, appropriate risk mitigation actions are decided and implemented.

E**xample:** Having found high rates of decent, the Standard Operating Procedures (SOPs) are changed to improve aircraft control for optimum/maximum rates of decent.

Effectiveness monitored*.* Once a remedial action has been put in place its effectiveness is monitored, confirming that it has reduced the identified risk and that the risk has not been transferred elsewhere.

Example: Confirm that other safety measures at the airfield with high rates of decent do not change for the worse after changes in approach procedures.

This is the critical part of the process. Given the systems are put in place to detect, validate and distribute the information, it finally reaches the areas where the safety and continued airworthiness benefits may be realized. The data must be assessed using first hand knowledge of the operational or airworthiness context in which it is set. Final validation done at this informed level may still weed out some erroneous data.

Example of follow-up: During a routine analysis of go-arounds it was found that one had a delay of over 20 seconds between flap selection and raising the gear.

3.7. Remedial Action

Once a hazard or potential hazard has been identified, then the first action has to be to decide if the level of risk is acceptable. If not, then appropriate action to mitigate the effect should be investigated along with an assessment of the fuller effects of any proposed changes. This should ensure the risk is not moved elsewhere. The responsibility for ensuring action is taken must be clearly defined and those identified must be fully empowered.

Example of Remedial Action: In the go-around case described above, the operator-included go-arounds in the next simulator check sessions. These highlighted how easy it was to miss the gear action if the “positive climb” call was missed by the manhandling pilot. It stressed the importance of a team effort during go-arounds.

3.8. Continued Analysis

Once any action is taken, then an active monitor should be placed on the original problem and a careful assessment made of other hazards in the area of change. Part of the assessment of the fuller effects of changes should be an attempt to identify potential relocation of risks. This, plus a general monitor on all surrounding measures is required before “signing off” the change as successful. This confirmation, or otherwise, would be expected to feed into a high-level management group to ensure remedial action takes place.

Chapter 4 FDA within a Safety Management System

The principles behind successful Safety Management Systems (SMS) are the same as those for FDA programmes that have been proven to function much more effectively within an integrated risk management system. This chapter gives an outline of what a Safety Management System is and how a FDA programme functions within it.

4.1. Safety Management Systems (SMS)

4.1.1. What is a Safety Management System?

ICAO Annex 6 Part 1 mandates "an operator shall establish an accident prevention and flight safety programme. ICAO Doc 9422 (Accident Prevention Manual) gives appropriate guidance material and describes a risk management process that forms the basis of an operator's SMS. The recently introduced Manual of Accident Prevention Programme (Ed.2005) also describes in detail the FDA programmes and the Safety Management Systems.

There are three essential prerequisites for a Safety Management System. These are:

- A comprehensive corporate approach to safety,
- An effective organization for delivering safety, and
- Systems to achieve safety oversight.

The systems required may include:

- Arrangements for the analysis of Flight Data.
- Enhanced Safety Event/Issue Reports.
- Internal Safety Incident Investigations leading to Remedial Action.
- Effective Safety Data for Performance Analysis.
- Arrangements for ongoing Safety Promotion.
- Planned Safety Audit Reviews.
- Periodic review of the SMS.
- Active Analysis by Line Managers.

'**Safety Management**' is defined as the systematic management of the risks associated with flight operations, related ground operations and aircraft engineering or maintenance activities to achieve high levels of safety performance.

A 'Safety Management System' is an explicit element of the corporate management responsibility that sets out a company's safety policy and defines how it intends to manage safety as an integral part of its overall business.

4.2. The Safety Culture

4.2.1. Safety Management Policy

The operator should have a top-level commitment to a business objective that minimizes the aviation accident risk to as low a level as reasonably practicable. There will be a commitment to a pro-active approach to systematic safety management that all levels of individuals involved are aware of and are held accountable for.

4.2.2. Open Safety Conscience

The FDA programme can best function in an environment where there is already a strong safety culture. A willingness to pinpoint potential risks in oneself, others and third parties in such a way that remedial actions are taken in a non-punitive manner is essential.

4.2.3. Involvement at all Levels

The safety Analysis process involves all levels within an organization. Anyone believing they have identified a potential risk should feel able to report and expect follow-up action to be considered. Generally in FDA programmes the principal source of involvement is of course the flight deck crew, although ATC, maintenance etc. will occasionally be involved. From the line pilot to the fleet manager all have responsibility to act.

4.2.4. Learning not Blaming

As with all safety reporting systems involving people's shortfalls or errors, it is difficult to overcome the natural human tendency to cover up mistakes. It is therefore essential to do away with the stigma attached to owning up (to an ASR) or in this case being approached about circumstances detected by the FDA system. Methods used in successful Air Safety Reporting systems should be employed here.

4.2.5. FDA Integrated within the Safety Management System

An FDA programme held remote from all other safety systems of an Operation will produce lower benefits when compared with one that is linked with other safety Analysis systems. This other information gives context to the FDR data which will, in return, provide quantitative information to support investigations that otherwise would be based on less reliable subjective reports. Air safety reporting, avionic and systems maintenance, engine Analysis, ATC and scheduling are just a few of the areas that could benefit.

4.2.6. The Safety Culture covers all Safety Analysis Systems

The culture must cover, bring together and integrate information from the many diverse sources of data within the operator. FDA, Air Safety Reporting, Technical and Continued Airworthiness Reporting, Ground Incidents, Design and finally Human Factor Reporting systems must be linked together to produce a best estimate of operational risks. Where necessary these links may have to be configured to restrict data identification while passing useful information.

4.2.7. Management and Crew's Responsibility to Act upon Knowledge

Once an area of risk has been identified then a documented/trackable decision must be made. Either remedial action should be taken, projecting the likely reduced risk, or justification for maintaining current status. Without this process in place, then the consequences of not acting upon risk information may be severe. The FDA process would be expected to be continuously audited for fulfillment of this aspect by a high-level safety board or similar group.

4.2.8. Good Written Agreements - Not Over Detailed but Strong on Principles

It is important that the underlying principles to be applied are understood by all parties and signed up to, early in the process. Once this is done, when problems or conflicts of interest arise, they form the foundation of practical solutions. Everyone involved should know the limits, which the agreements place on them. In uncertain cases there should be an accepted procedure by which a course of action can be approved.

Airline management and pilots both have legimate concerns regarding the protection of FDA data, for example:

a) Use of data for disciplinary purposes;

b) Use of data for enforcement actions against individuals or against the company, except incases of criminal intent or intentional disregard or safety;

c) Disclose to the media and the general public under the provisions of State laws for access to information; and

d) Disclose during civil litigation

The integrity of FDA programme rests upon protection of the FDA data. Any disclosure for purposes other than accident prevention can compromise the voluntary provision of FDA data, thereby compromising flight safety. Thus, the prevention of misuse of FDA data, is a common interest of the state, the airlines and the pilots.

As with any successful incident reporting system, the trust established between management and its pilots is the foundation for a successful FDA programme. This trust can be built on:

a) Early participation of the pilots' association in the design, implementation and operation of the FDA programme;

b) A formal agreement between management and the pilots identifying the procedures for the use and protection of data; and

c) Data security, optimized by:

i) Adhering to stringent agreements with the pilots' associations;

ii) Strictly limiting data access to selected individuals within the company;

iii) Maintaining tight control to ensue that identifying data are removed from the flight data records as soon as possible;

iv) Ensuring that operational problems are promptly addressed by management;

and

v) Destruction of all identified data as soon as possible.

Appendix C gives an example of a typical agreement detailing the procedures to be used and the operator-crew agreement.

4.2.9. Implementing an FDA Programme

Typically, the following steps are required to implement an FDA programme:

a) Implementation of pilot association agreements;

b) Establishment and verification of operational and security procedures;

c) Installation of equipment;

d) Selection and training of dedicated and experience staff to operate the programme;

and

e) Commencement of data analysis and validation.

Bearing in mind the time required to get crew/ management agreements and procedures developed, start–up airline with no FDA experience would not likely achieve and operational system in less than 12 months. Another year may be required before any safety and cost benefit appear. Improvements in the analysis soft wear, or the use of outside specialists service providers, may shorten these time frames.

Integrating the FDA programme with other safety monitoring systems in to a coherent safety management system will increase the potential benefits. Safety information gathered from other programmes of the SMS guilds context to the FDA data. In turn, FDA can provide quantitative information to support investigations that otherwise would be based on less reliable subjective reports.

4.3. Risk Identification

4.3.1. Definition of Risk, Probability and Safety Criticality

Risk is defined as the combination of probability, or frequency of occurrence of a defined hazard and the magnitude of the consequences of the occurrence.

Safety criticality classifications.

First Severity:

	Category	Results in one or more of the following effects
4	Catastrophic	• Loss of the aircraft • Multiple fatalities
3	Hazardous	• A large reduction in safety margins • Physical distress or workload such that the flight crew cannot be relied upon to perform their tasks accurately or completely • Serious or fatal injury to a relatively small number of occupants
2	Major	• Significant reduction in safety margins • Reduction in the ability of the flight crew to cope with adverse operating condition impairing their efficiency • Injury to occupants
1	Minor	• Nuisance • Operating limitations or emergency procedure

The probability of occurrence, or likelihood, gives an indication of order of magnitude:

	Probability of Occurrence	Quantitative Definition	Qualitative definition
1	**Extremely improbable**	• less than 10-9 per flight hour (See note)	• Should virtually never occur in the whole fleet life.
2	**Extremely remote**	• between 10-7 and 10-9 per flight hour	• Unlikely to occur when considering several systems of the same type, but nevertheless, has to be considered as possible.
3	**Remote**	• between 10-5 and 10-7 per flight hour	• Unlikely to occur during total operational life of each system but may occur
4	**Probable**	• between 1 and 10-5 per flight hour	• .several times when considering several systems of the same type. • May occur once or several times during operational life.

Note: *The use of mathematical probability is not essential. They are included to give an indication of order of magnitude when making qualitative estimates.*

Finally, these two aspects are brought together in a risk tolerability matrix that defines the maximum rate of occurrence allowed for any particular effect of event. The table below shows the **minimum** safety performance standards that should be applied, although depending on the safety significance given to each risk the actual standards required may be higher.

Quantitative Probability	10	10-1	10-2	10-3	10-4	10-5	10-6	10-7	10-8	10-9
Qualitative Proby. of Occurrence	FREQUENT			REASONABLY PROBABLE		REMOTE		EXTREMELY REMOTE		EXTREMELY IMPROBABLE
Category of Effect	MINOR					MAJOR		HAZARDOUS		CATASTROPHIC

4.3.2. Determining what is Acceptable

In practical terms, experience can be displayed as a risk tolerability matrix. While this approach can offer guidance to the safety analyst, much rests on the appreciation of the seriousness of the incident and, most critically, upon the understanding of potential risk. Just because there was a safe outcome to a particular incident scenario, this does not necessarily make it a low severity incident. The mitigating component may not always be present.

Examples of incidents with a high risk potential that on the (good) day resulted in no damage: A very severe wind-shear, rather than resulting in a prompt go-around, is flown through to landing, A long landing after a hurried approach did not result in an overrun because that particular runway had a good braking coefficient; a crew's slow response to a GPWS Glide slope warning was not a problem as the aircraft was on the centerline and not on a terrain critical approach.

4.3.2.1. The Initial Risk Assessment

Knowledge of the current operation is needed to formulate an assessment of the total risks falling upon the operator. This can be gained, in part, using a carefully implemented FDA programme that will provide identification and measures to support expert opinion and experience. All available sources of safety data should be utilized to better model the risk environment. The better the understanding of risk, especially at the less obvious lower risk levels, the more likely that potential risks will be highlighted and in those areas mitigation techniques can be developed.

Example: the probability of a CFIT accident may be arrived at by examining a combination of world accident trends, operator's safety reports, FDA Exceedence data, FDA routine measurements, airport assessments etc.

4.3.2.2. Giving a Baseline against which to Measure Change

The results of the FDA analysis used in the initial assessment will then form the baseline against which to measure future changes. It will be able to identify both shortfalls and improvements in risks.

Example: the distribution of touchdown points can be used to detect changes in pilot technique, long touchdowns on short runways, changes in turn-off availability resulting in heavy braking, high threshold speeds due to changed ATC requirements etc.

4.3.2.3. Historical and Predicted Risks

The link between measurable past risk levels and potential future risks is important but difficult to quantify. While historical data on realized risk is useful, it only serves to identify mitigation targets - that is the traditional approach to accident investigation and follow-up. FDA, and indeed all other risk defining data needs to be rather more subtly analyzed and extrapolated forward to become a predictive tool. With imaginative and methodical analysis, historical data can enable the analyst to develop causal factor models that can help identify lower level precursors than even the causal factors.

Example: heavy braking during taxiing vs. ground collisions; touchdown points vs. overruns/undershoots; glide slope/ localizer tracking vs. GPWS or CFIT.

4.3.2.4. Measuring Actual and Potential Risk Levels

Most risk level indicators deduce the probability of physical harm based on incidents and measures in the past. While this will allow an SMS failure to be detected after the event, what is really required is a predictive Analysis system. The aim of this would be to flag up the trend of a much lower level measure towards the exceedances of an acceptable level of hazard before that level has been reached.

Example: changing distributions of runway distance remaining at touchdown vs. calculated stopping distance may indicate a trend towards a potential overrun.

4.3.2.5. Looking for Trends Towards Mitigation Levels of Risk Covered by SMS

A method should be established to detect a trend towards unacceptable risk prior to it reaching that level. Thus, a second level of defense is created in addition to the traditional mitigating action.

Example: if there was an increase in the underlying distribution of threshold speeds then there would be a higher probability of go-arounds. Individual exceedences would indicate higher risk instances.

4.3.2.6. Recording Safety Breaches of SMS Risk Mitigation Procedures

Where SMS has identified a risk and then considered that risk has been reduced by mitigation laid down in SOPs, then any failure to exercise that procedure should be identified and investigated.

Example: unstable approaches below the minimum acceptable height without a go-around may indicate a training shortfall or unclear SOP.

4.3.2.7. Highlighting Risk Areas not Identified by SMS

The SMS process depends on a combination of recognized sources of risk combined with a safety net that will catch unpredicted risks before they are realized. The generalized FDA programme will help form one layer of this net. When SOPs have failed to prevent a breach of the set down hazard level then these must be recorded in sufficient detail to allow analysis to identify appropriate remedial action.

Example: By looking for altitude deviations a wide range of potential problems may be detected including: changed or difficult ATC clearances and commands, TCAS warnings, pilot errors, turbulence, etc.

4.3.3. How an SMS can Benefit from FDA

4.3.3.1. FDA Provides Definitive Risk Data to Validate Assumptions

The success of any SMS requires knowledge of actual operations and cannot be achieved using assumed safety performance. One cannot know with any certainty that, because one audit point, say a check flight, measures up to standards, that the other 1000 flights will also be satisfactory. In Analysis all flights, FDA can help to fill in this missing information and assist in the definition of what is normal practice. This gives assurance that SMS is managing actual rather than perceived safety issues.

4.3.3.2. A Summary of SMS Benefits from the Implementation of FDA

1. Gives a knowledge of actual operations rather than assumed.
2. Gives a depth of knowledge beyond accidents and incidents.
3. Setting up a FDA program gives insight into operations.
4. Helping define the buffer between normal and unacceptable operations.
5. Indicates potential as well as actual hazard.
6. Provides risk-modeling information.
7. Indicates trends as well as levels.
8. Can provide evidence of safety improvements.
9. Feeds data to cost-benefit studies.
10. Provides a continuous and independent audit of safety standards.

4.3.4. How FDA can Benefit from Incorporation within a SMS

4.3.3.3. SMS Provides a Structured Environment for a FDA Implementation

The implementation of FDA has increased gradually over the last 30 years as analysis techniques and data recording technologies have improved. As a result, the processes used have tended to be rather adhoc, locally implemented and controlled by informal procedures with less than ideal "check and balance" records after issues have been raised and actioned. It says a great deal for the individuals concerned and the undeniable evidence produced that, despite this lack of established process, many significant safety issues have been raised and resolved. However, the techniques are now sufficiently mature to enable a more formal process to be constructed along the lines of other SMS processes.

4.3.3.4. A Summary of FDA Benefits from the Incorporation within a SMS

1. Formal recognition and buy-in by operator's management.
2. Formalization of assessment and action process.
3. Integration with other safety information.
4. Auditable benefits and evidence of "best endeavors".
5. Allows regulatory bodies to take into account the pro-active process.

Chapter 5 Planning and Introduction of FDA

This chapter describes the development and implementation of FDA within an operator. It is recognized that there are a wide range of operators covered by the FDA requirements and that there is no “one size fits all” system. The size and age of aircraft may determine the parameters available for analysis. The programme effectiveness and efficiency of a small fleet or operation may be helped by pooling analysis within a group of similar operations. While retaining responsibility for risk assessment and action, some operators may wish to contract out the basic analysis due to lack of expertise or resources.

5.1. FDA Guiding Principles Checklist

As an aid to operators, **Appendix D** provides a checklist of guiding principles that highlight some of the fundamental concepts that should be considered when putting one of these pro-active safety processes in place.

Principles covered:

1. Definition
2. Accountability
3. Objectives
4. Flight Recorder Analysis Techniques
5. Flight Recorder Analysis Assessment and Process Control Tools
6. Education and Publication
7. Accident and Incident Data Requirements
8. Significant Risk Bearing Incidents Detected by FDA
9. Data Recovery Strategy
10. Data Retention Strategy
11. Data Access and Security
12. Conditions of Use and Protection of Participants
13. Airborne Systems and Equipment

5.2. FDA Programme Costs and Benefits

Much has been said about the safety benefits of FDA programmes and this has been followed by evidence of potential cost savings to offset the, not insignificant, set-up and running costs. Unfortunately, detailed cost breakdowns are not available.

Appendix E gives indications of areas of cost and benefit that should be considered when the business case is being constructed.

By far the largest cost element to be considered is the unacceptable cost of having an accident that could have been prevented. This (theoretical) cost has in the past driven individual operators out of business. Even if this is not the case there will be significant loss of revenue through loss of public confidence, loss of utility of an aircraft and a reduction in company stock-market value.

The more tangible costs are non-recurring set up costs and running costs. The latter will include both the support costs of engineers and technical staff plus the operational staff needed to assess the data and make decisions upon actions required.

Finally, there are a wide range of potential benefits additional to the primary safety benefit. When used imaginatively, the data has been found to produce significant engineering and operational savings. When planning this, care must be taken to ensure the security of identified data to stop inappropriate crew contact or identification on operational matters.

5.3. The Implementation Plan

This is a broad guide to the major steps involved in putting an FDA programme in place. The key steps are getting buy in at the top level of management, a good team with crew participation, clear objectives and specification and finally, rigorous testing and verification procedures for the resulting data.

1. Confirm CEO approval and support for FDA implementation.
2. Identify Key team members.
3. Agree Aims and Objectives.
4. Develop crew agreements and involvement.
5. Conduct feasibility study and develop business plan-people, processes, software and hardware
6. Obtain funding and organizational approval.
7. Survey key areas in Operation for targets of opportunity.
8. Produce detailed specification and place contracts.
9. Put in place operating procedures.
10. Installation of airborne equipment (if required).
11. Provision of ground analysis station.
12. Conduct staff training.
13. Test data acquisition and analysis, complete manuals.
14. Produce Completion Report.

5.4. Aims and Objectives

5.4.1. Define Objectives of Programme

As with any project there is a need to define the direction and objectives of the work. A pre-planned, staged approach is recommended so that the foundations are in place for future expansion into other areas. Use building blocks that will allow expansion, diversification and evolution through experience.

Example: Start with a modular system looking initially at basic safety related issues only but with engine health Analysis etc. added in the second phase. Ensure compatibility with other systems.

5.4.2. Set Both Short and Long Term Goals

A staged set of objectives starting from the first week's replay, moving through early production reports into regular routine analysis, allows the system to "tick-off" achievements.

Example: Short term

(a) Establish data download procedure, test replay software, identify aircraft defects.
(b) Validate and investigate exceedence data.
(c) Establish a User acceptable routine report format to highlight individual exceedences and also statistics.

Medium term

(a) Produce annual report - include key performance indicators.
(b) Add other modules to analysis (e.g. Continued Airworthiness).
(c) Plan for next fleet to be added to programme.

Long Term

(a) Network information across company information systems.
(b) Ensure FDA provision for any proposed "Advanced Qualification Program" style training.
(c) Use utilization and condition Analysis to reduce spares holdings.

5.4.3. Aim for Known "Hot Spots"

In the initial stages it is useful to focus on a few known areas of interest that will help prove the system's effectiveness. This is rather more likely to get early success than a "scatter-gun" approach which, if properly constructed, should eventually hit these spots but will probably not get results as quickly.

Example: Hurried approaches at particular airports, rough runways, fuel usage, poor autopilot reliability. Analysis of known problem airports may generate Analysis methods for all locations.

5.4.4. Do not Oversell First Phase

Everyone has to understand the objectives of the programme. If the expectations of the information users are too high then the project will always fail. By keeping the objectives within reach at each stage of the project then the steps are easier and less likely to fail.

5.4.5. Record Successes and Failures

Having set staged objectives of the project then all successes and failures should be recorded. This will form the basis of a review of the project and the foundation of future work.

5.5. The FDA Team

Experience has shown that the "team" required to run an FDA programme can vary in size from one person with a small fleet (5 aircraft), to a dedicated section for a large fleets. The description below identify the various functions to be fulfilled, within a larger system in some detail. Not all of these functions need a dedicated position.. Most of the aspects covered will still be required in a smaller scale system but would be handled by one individual in a "multi-role" function. In this case other areas, for example engineering, would provide part time support.

In addition to their existing subject area expertise, all staff should be given at least basic training in the specific area of FDR data analysis. It is essential that a regular, realistic amount of time is allocated to FDA tasks. Lack of manpower resources usually results in underperformance or even failure of the whole programme.

In the case of a very small operator the day to day running of the programme may be contracted out to a third party, thus removing the data handling and basic analysis tasks. However, sufficient expertise must remain within the operation to control, assess and act upon the processed information received back from the other company. Responsibility for action may not be delegated.

5.5.1. Team Leader

Team leaders must earn trust and the full support of both management and flight crews. They act independently of other line management to make recommendations that will be seen by all to have a high level of integrity and impartiality. The individual will have good analytical, presentation and management skills.

5.5.2. Flight Operations Interpreter

This person will normally is a current pilot (or perhaps recently retired senior Captain or trainer) who knows the company's route network and aircraft. They're in depth knowledge of SOPs; aircraft handling characteristics, airfields and routes will be used to place the FDA data in a credible context.

5.5.3. Technical Interpreter

This person interprets FDA data with respect to the technical aspects of the aircraft operation. He is familiar with the power plant, structures and systems departments' requirements for information and any other engineering monitoring programmes in use by the airline.

5.5.4. Aircrew Representative

This person will be the link between the fleet or training managers and aircrew involved in circumstances highlighted by FDA. This position required good people skills and a positive attitude towards safety education. The person is normally a representative of the flight crew association and should be the only person permitted to connect the identifying data with the event. The aircrew representative requires the trust of both crewmembers and managers for their integrity and good judgment.

5.5.5. Engineering Technical Support

This person is normally an avionics specialist, involved in the supervision of mandatory serviceability requirements for FDR systems. They must be knowledgeable about FDA and the associated systems needed to run the programme.

5.5.6. Air Safety Coordinator

This person cross-references FDA information with other air safety monitoring programmes (such as the company's mandatory or confidential incident reporting programmes), creating a credible integrated context for all information. This function can reduce duplication of follow-up investigations.

5.5.7. Replay Operative and Administrator

Responsible for the day-to-day running of the system, producing reports and analysis. Methodical, with some knowledge of the general operating environment, this person is the "engine room" of the system.

5.6. Technical Specification

5.6.1. Data Recording Technology

This section gives a brief outline of some of the current technologies applicable to FDA.

Mandatory Crash Recorders
ICAO Annex 6 Part I paragraph 6.3 describes the carriage requirements for flight data recorders. Attachment D describes mandatory parameters to be recorded by the recorders.

Types of mandatory crash recorder include:

• **Tape Based - DFDR** (Digital Flight Data Recorder) – typical capacity 25 hours at 64/128 WPS (words per second), minimum download time 30 minutes, problems of tape spooling due to high speed downloads - frequent replays affect serviceability.

• **Solid State** – **SSDFDR** – typical capacity 25/50 hours at 64/128 WPS but trend to increasing this capacity, minimum download time five minutes, no effect on serviceability. Many SSDFDRs are supplied with small hand held download units.

• **Combined Voice and Data** - **SSCVDFDR** - solid state with voice and data modules. Data specification as for basic SSDFDR. Voice records must not be made available to any unauthorized staff.

• **Quick Access Recorders (QARs)**
Quick Access Recorders are normally fitted on a "no hazard-no credit" basis. They should satisfy the environmental test requirements specified for the equipment. General standards, naming conventions etc. should be applied where appropriate to enable common software and interpretation with the DFDR system.

• **Tape** (QAR) - traditional medium for FDA work. These vary with tape length and recording density to give capacities between 10 hours at 64 WPS to 20 hours at 256 WPS or more. The tapes need specialist replay hardware and are replayed at up to 100 times real time.

• **Optical disk** (OQAR) - developed from standard PC technology with environmental protection, a capacity of up to 200 hours at 256 WPS is available. Capacity normally far exceeds required time between downloads. Data files accessible by standard PC hardware still require engineering decode and display software. Replay rates are much higher than for tape.

• **PCMCIA** (CQAR or PQAR) - Mainly using flash memory, this is a very reliable and compact medium that lends itself to small installations such as commuter aircraft or helicopters. Capacity was originally not as high as OQAR but have increased rapidly. Because of their size and relatively high value, the cards are easy to lose. Some aircraft Data Management Units (DMU) have provision for a card built in.

• **Mini QAR** - There is also a small solid-state recorder that is plugged into the auxiliary output from the mandatory recorder. This device has 400-hours+ capacities and provides a simple QAR installation at low cost. This removes the pressure for frequent downloads before the data is overwritten.

• **Solid state** – Some Flight Data Acquisition Units (FDAU) have the capacity to retain data ready for fast download to a portable device or most recently via wireless link directly into an operator's system.

5.6.2. The QARs;

available on most large, modern aircraft can be analyzed on a suitably configured replay and analysis system. Even though the operators themselves can configure the various event equations and exceedence levels, suppliers of ground replay soft wear offer both starter packs and advanced flight operations monitoring programmes for a variety of different aircraft types. It is not normally cost-effective for new operators to configure FDA systems themselves, although most suppliers will review the relevance and levels of event triggers with each new operator.

5.6.3. Maintenance Recorder Downloads

Some aircraft manufacturers actively support FDA programmes for their aircraft. They provide airlines with packages including tools and soft wear, handbooks to support their flight data analysis methods and procedures, and additional assistance for operators implementing their programme. (They see the sharing of data and information provided by the airline as a means for improving their aircraft, SOPs and training).

Most system vendors provide one year of maintenance and support in the original package but charge and annual fee thereafter. In addition, other cost factors to be considered by prospective purchasers include:

a) Installation costs;
b) Training costs;
c) Soft wear upgrade costs (Often included in he maintenance contacts); and
d) Other software Licence fees that may be necessary

5.6.4. Remote Transmission of Data

In the past, some operators have started programmes by downloading data from the mandatory crash recorder. This method of obtaining data gives a foundation on which to test run prior to a full QAR system. However, it used to be rare for recovery rates of more than10 percent to be achieved in practice due to logistical and serviceability problems with the tape-based recorders. However, today solid-state recorders can be used to produce as good coverage as dedicated QARs. The limiting factor here is the time available before the data is overwritten-typically 25 or 50 flying hours.

These DFDR downloads are already required from all operators for the investigation of Mandatory Occurrence reports. (Details of the JAR-OPS 1 subpart 1.160 requirements are given in chapter 8). Subject to CAASL approval and procedural limitations, it may be possible that QAR data may be an acceptable substitute if the QAR holds all the required DFDR data parameters.

5.6.5. Maintenance Recorder Downloads

Standards PC floppy disks are the normal medium used to download systems information associated with maintenance tasks and records. These are normally used by the Airborne Condition Monitoring Systems ACMS) present on most new aircraft today. The system allows a small amount of data, usually limited to snapshots, to be downloaded.

5.6.6. On board Analysis

A few operators have implemented on-board monitoring programmes that perform analysis almost in real time. This has the advantage that only small amount of data, surrounding the interesting event, need to be transferred. The disadvantage is that if this snapshot is only data available, then information on the pre and post incident context is lost. Alternately, it is possible to use on-board analysis as the trigger mechanism for a post-flight action to download all the data stored for analysis. An on board system linked to the operator's base via ACARS has been evaluated.

5.6.7. Remote Transmission of Data

Recent developments in the transmission of high volume data over short ranges of up to 1 or 2 miles indicate that a secure, encrypted "wireless" system is practical. The onboard system transmits the flight data as the aircraft taxi in to the terminal and it is the transferred using the operator's information network. The system provides a fast and automatic means of data transfer that will be used for a number of tasks including navigation database updates, flight plans, passenger lists, digital movies etc. The raw data transmission rates are in the order of 11 Mega bits of data per second, opening the way for imaginative information exchange.

Finally a method of download, after landing, using a number of mobile phones is being developed. Like the previous system this will download "packets" of encrypted information via the mobile phone network, reducing the need for expensive airport equipment. The mobile phone installation and the protection from inadvertent airborne functions would have to be approved by the CAASL.

5.7. Analysis Program Specification

An analysis program specification document has to be constructed to fulfill two principal requirements. Firstly, to set down the complete process by which flight data can be turned into useful information and secondly, to provide the system programmer with sufficient detail to code the data conversion and analysis software. This requires a detailed technical specification of the aircraft data systems that will involve considerable research to ensure valid data extraction. This document is likely to form an integral part of any contracts placed for the supply of a system but will continue to develop as the system matures and is refined.

5.7.1. Process Definition from Aircraft to Archive

This will detail the download and data transfer methodology, serviceability and replay statistics, the analysis modules, exceedances workflow (allocation of responsibility, investigation results, actions taken…), and archiving and historical records.

5.7.2. Complete Documentation Including Reasoning and all Changes

It is critical that the system is fully documented so that not only the construction of the system is transparent but also the reasoning behind the code is clear to future users. Changes, updates and fixes should be detailed and the implementation date recorded. Where a historical event record is being maintained then previous standards of event logic and limits should be available and referenced to past event trends.

5.7.3. Thorough Testing Procedures - Both Initial and Ongoing

The testing of the program should encompass the following aspects:

• **Testing basic data replay and conversion to engineering units** - this can be relatively simple for the principal variable parameters but very difficult for many discrete that are never seen during normal operations.

• **Testing exceedances detection** - This can be tested either by realistically manipulating normal data to simulate an event, by reducing the event limits such that normal flying will trigger events, or more acceptably, replaying historical data known to contain incidents that should trigger events.

• **Ongoing tests** - It is important to have a means of ensuring that the quality of the system does not change after any significant program modification. Additionally, a routine, say annual, ”health check” to pick up and resolve any unforeseen problems would be advisable and could be usefully incorporated with the routine DFDR serviceability checks.

5.7.4. Exceedence Detection

This is the traditional approach to FDA that looks for deviations from flight manual limits, standard operating procedures and good airmanship. There is normally a set of core events that cover the main areas of interest that are fairly standard across operators. See **Appendix A, paragraph 1**.

Example: High lift-off rotation rate, stall warning, GPWS warning, flap limit speed Exceedence, fast approach, high/low on glide slope, heavy landing. There will be additional safety related events that will produce useful information to supplement pilot air safety reports.

Example: Reduced flap landing, emergency descent, engine failures, rejected takeoffs, go-around, TCAS warning, handling problems, system malfunctions, pilot marked event.

Given the wide range of risk levels covered, it would be useful if an informed estimate of the risk, no matter how subjective, could be included. This will help focus attention on the higher risk events rather than just numbers.

Example: Equate the risk levels to a major warning such as a stall or GPWS warning that require direct crew intervention to prevent a catastrophe. Deduce a rule of thumb that may give say a 50 degree bank angle at 400 ft an equivalent risk to the GPWS and 30 degrees at 5000 ft a 10% risk.

5.7.5. Modified Standard Event Limits to Reflect Operator's SOPs and Requirements

A basic set of events provided by suppliers will need to be modified to tie in with the operator's SOPs. A direct read across will make interpretation of the results much easier and will need to be updated if SOPs change over time.

Example: If SOPs require the aircraft to be in landing configuration by 1000 ft AAL then setting three trigger levels at 1000, 800 and 600 ft give a range of significance covering the normal to the exceptional.

If there is a problem with SIDs at a particular airfield producing nuisance events, build a location condition into the event rather than lose the benefit of the event at all other locations. This way a known "non-standard" SOP does not swamp the system and yet can still be monitored. However, the fact that a SOP produces an event may mean that its safety implications need reconsidering.

5.7.6. New Events For Specific Problem Areas

Where there are known areas of interest that are not covered by the standard set of events then it should be possible to add a new event. This also produces good user reaction as specific problems are being addressed in addition to less tangible safety benefits. See **Appendix A, paragraph 2**.

Example: Restrictions on the use of certain flap settings to increase component life. Detect and record number of uses.

5.7.7. All Flights Measurement

In addition to exceedences, most programs today retain various snapshots of information from every flight. This data is most useful in determining trends before there are statistically significant movements in event levels. Given data from most flights, the possibilities for substantial analysis breakdowns by time, location, aircraft weight etc. become more feasible than when using the, hopefully, small number of events. This approach to FDA data has proven very useful in determining what is normal as opposed to the event method that gives what is abnormal. See **Appendix A, paragraph 3**.

Example: Rotation rate at lift-off and it's correlation with take-off weight and location can point to inaccuracy in the training simulator's model, an airfield problem or a new pilot intake.

5.7.8. Onboard Eventing and Measurement

Some operators have used in-flight exceedances and measurement software to reduce the amount of data transferred. While this has been successful there still remains the requirement to store full flight data for ad-hoc enquiries and incident analysis. In addition the software standards required for airborne software are more rigorous than that on the ground. This, combined with the initial costs of system programming and the practical difficulties in implementing changes across a large fleet, has limited the spread of such systems. However, a number of aircraft manufacturers have implemented on-board systems that can be used along with QARs or just maintenance recorders giving “snapshots”. These are often used for engine, ETOPS and auto land reporting.

Chapter 6 Organization and Control of FDA Information

As with all information systems, it is critical that the data flows are tightly controlled by clear procedures. Careful thought has to be given to the practicalities and possible disruptions involved in getting data from the aircraft and translated to useful information for safety managers. Additionally, much of the data has to be treated confidentially with access carefully restricted to those authorized to view it. This section deals primarily with enabling the efficient handling of exceedances (or events) produced by an FDA programme. These exceptions to normal operating practice, good airmanship and flight manual limitations will be highlighted ready for evaluation and action.

6.1. Rationalized Data Stream

6.1.1. Regular Replay Schedule

Downloaded data should be replayed to a regular schedule to avoid build ups. Batch processing of a number of files may be a practical method of initial replay and analysis if the system is suitably automated.

6.1.2. Initial Verification of Data

The first step in the investigation process is to ensure the information is realistic and presents a consistent picture. VALIDATION IS CRITICAL. Before any action is instigated the basic FDR information must be thoroughly checked. Well written FDA software should automate as much of this process as practical.

6.1.3. Identification of Urgent Actions

There are a number of circumstances where FDA data will indicate that immediate safety action is required and a fast procedure to ensure safety critical remedial action should be defined. In general, the urgent actions are associated with Continued Airworthiness checks, rather than operational situations. For example, a very heavy landing with potential damage that has not been reported by other means should trigger relevant structural checks as soon as possible, whereas crew remedial investigations are not so urgent. Therefore, replays ideally should be completed and a basic initial examination of the results should be carried out before the next flight. When this is not practicable then a reasonable period of time after the flight should be specified.

Note that in an effective open safety culture the crew reporting of likely problems should be expected to alert the operator to the majority of these situations.

6.1.4. Allocation of Follow-up Coordinator

Once a basic assessment has been carried out and has revealed a significant risk, or aspect requiring further investigation, then one particular person or department should be allocated follow-up responsibility. This responsibility is normally fairly clearly defined by the type of incident. However, on occasions there may be a need to involve several departments or even organizations and in this case the follow-up coordinator will act as a focal point for the investigation.

6.1.5. Database all Results

The results of all analysis should be placed on a database ready for interpretation and further analysis. Generally it is best to automatically database all events detected and then mark as invalid those that are in error due to program or data anomalies. Experience has shown that a manual data entry of the event details is both time consuming and prone to error. Recording all erroneous events will assist in the later refinement and improvement of the program.

6.1.6. Record all Actions Taken

An important part of the assessment of a new FDA system and an integral part of a fully functioning system within a SMS is the careful recording of all actions arising from the data. This can be used to help demonstrate the benefits accrued and also ensure an audit path to confirm remedial actions have taken place.

Example: A heavy landing event –

Initial analysis action - validate and set event in context of previous hard landings
Action informee - structures, action taken - checks, result - no damage,
Action informee - operations, action taken - flying assessed - crew interviewed,
Result - revised crew briefing for airfield
Ongoing analysis action - monitor airfield events for recurrence or changes.

6.1.7. Replay Statistics

Part of the replay process should be the recording of statistics on replay coverage, individual aircraft reliability, general data quality measurements. Differences in replay success/errors between aircraft can help indicate where remedial engineering action is required. These statistics are required to allow the derivation of overall and specific event rates; airfield and aircraft specific rates etc.

Examples: Number of sectors and hours flown, replayed and analysed to give heavy landing events per 1000 landings or turbulence encounters per 1000 hours. Proportion of bad data by aircraft/recorder/tape/disk to identify problem areas.

6.2. Data Flow

The data flow should be optimized to minimize the delay between the flight and data analysis. This will ensure timely recognition of serious incidents that may need prompt action - for example a structural inspection - and increase the likelihood of the crew remembering the surrounding circumstances.

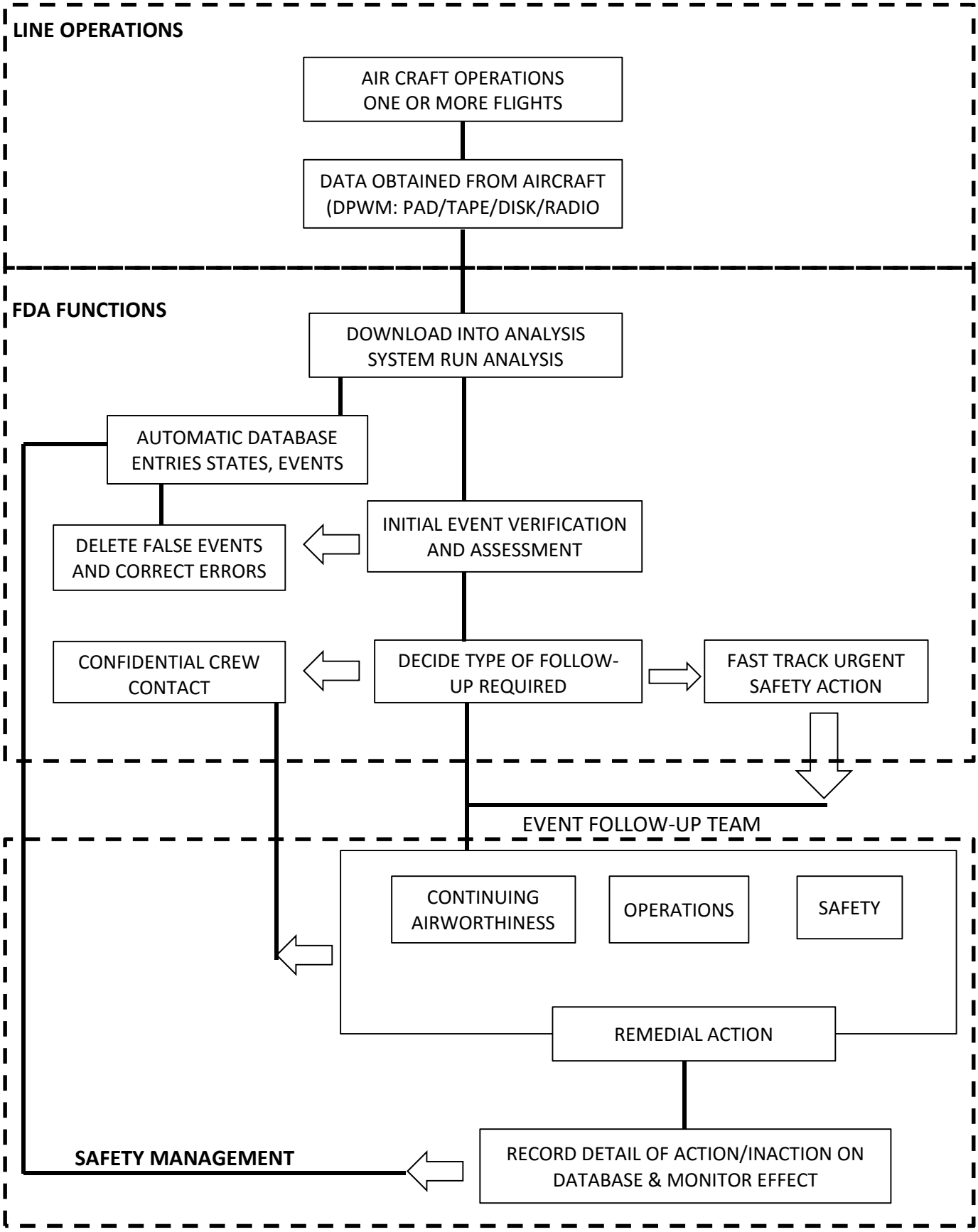


Figure 2 FDA Data Flow

6.3. Data Security and Control

6.3.1. Defined Policy on Retention of Data

Because of the large volumes of data involved, it is important that a strategy for data access, both on and off line, is carefully developed to meet the needs of the system users.

The most recent full flight and event data is normally kept on line to allow fast access during the initial analysis and interpretation stages. When this process is completed it is less likely that additional data from the flights will be required so the full flight data can be archived. Event data is usually kept on line for a much longer period to allow trending and comparison with previous events.

There are many hardware and software solutions to long-term data storage available off the shelf but the one selected must be compatible with the analysis software to allow practical access to historical data.

In most systems, data compression and the removal of non-essential parameters can reduce the capacity required. Also at this time removal of identification data can be completed.

6.3.2. Link with the Air Safety Reporting Process

This is required to allow relevant crew Air Safety Reports (ASR) to be automatically added to FDA information. Low significance incidents/events that are not subject to mandatory occurrence reporting would not normally be identified (see para 3.5 below). Care has to be taken where there has been no ASR submitted for an apparently reportable incident detected by the FDA programme. The crew should be encouraged to submit an ASR without prejudice via a confidential contact method.

6.3.3. Engineering use of FDA Data

It must be recognized that the use of FDA and associated data sources for Continued Airworthiness purposes are an important component of the system. For investigation of say potential heavy landing damage, there will be a need to identify the aircraft concerned and in the case of a technical defect report, the data associated with that particular flight may prove invaluable in fixing the fault. However, secure procedures must be in place to control access to the identified data and how the data is used. Identification of and contact with crews for operational rather than technical follow-up of FDA data should not be permitted through this path.

6.3.4. Defined De-identification Policy and Procedures

This is an absolutely critical area that should be carefully written down and agreed before needed in extreme circumstances. Management assurance on the nondisclosure of individuals must be very clear and binding. The one exception is when the operator/crew team believe that there is a continuing unacceptable safety risk if crew specific action is not taken. In this case an identification and follow-up action procedure, previously agreed before the heat of the moment, can be brought into play.
Experience has shown that this is very, very rarely required. Most often a crew responds to advice from the crew representative to submit an ASR and they are then covered by protection assured under that programme.

There must be an initial stage during which the data can be identified to allow confidential follow up by the crew representative or agreed, trusted individual. Strict rules of access must be enforced during this period.

In the case of a mandatory occurrence or accident, any data retained by the programme may not be de-identified or removed from the system prior to the investigation or confirmation that it is not required. This will allow the air safety investigators access to all relevant information.

6.3.5. Crew Identification in Mandatory Occurrences

An exception to the de-identification of FDA data should be made when there is an incident that is subject to a Mandatory Occurrence Report. In this case the identified data must be retained for any subsequent safety investigation.

6.3.6. Set Authorized Access Levels

The FDA system must have the ability to restrict access to sensitive data and also control the ability to edit data. The System Administrator should have full access, while operations management may only have sight of de-identified data and the ability to add comments and edit a few appropriate fields. Similarly the replay technician will be able to feed in new data, check identification etc. but will not be able to change program specifications and event limits. Continued Airworthiness and operations would have particular views of the data, perhaps with the former being airframe identified, while the latter would by say, pilot group.

6.4. Crew Participation

6.4.1. Agree Joint Aim - to Improve Safety and Non-punitive

It is fundamental that all involved in FDA agree the aims and objectives of the work and the self-imposed restrictions which operate. The improvement of safety standards is accepted as a worthy goal by all aviation professionals but the method of achieving it is more difficult to agree. By fully sharing the objectives and concerns of all parties, the possibility of misunderstanding are reduced.

6.4.2. Flexible Agreement

It has been found that agreements of principles, with plain English definitions of the areas covered, exclusions and conditions of use, are far more workable than a rigid set of rules that impede progress. Based on trust and mutual consent, all parties should view the data access as privileged and handle it carefully.

6.4.3. Defined Procedure for Restricted Contact with Flight Crew

A step-by-step description of the restricted method by which crews are contacted and the safeguards in place should be publicized to gain crew confidence. The aims of the contact along with the approach to debriefing and raising actions should be clear. Flight crews should be encouraged to talk through difficult situations and learn from experience, even to ask for data about their flying. As with air safety reporting, a willingness to communicate and learn is a good indicator of a successful safety culture. It is suggested that debrief tools including traces and visualizations/ animations would, in some cases, be useful during this process.

6.4.4. Discrete Retraining of Individuals where Required

Where it is agreed with the individual that retraining is appropriate then this should be scheduled into the training programme in a discrete manner to avoid highlighting the person. It must be stressed that additional training is not to be considered disciplinary action but merely a safety improvement action. Note that while an individual co-pilot may be placed into a programme of continuation training fairly easily, a captain may be more difficult to schedule in unobtrusively.

6.4.5. Confidentiality

A statement of agreement outlining the protection of the identity of the individual should be clearly written, along with any provisos necessary. An example of such wording as may be used by Director General of Civil Aviation in respect of the Mandatory Occurrence Reporting Scheme is as follows:

“It is fundamental to the purpose of the Scheme that the substance of the reports should be disseminated where necessary in the interests of flight safety. Without prejudice to the proper discharge of responsibilities in the regard, the CAA will not disclose the name of the person submitting the report or of a person to whom it relates unless required to do so by law or unless in either case the person concerned authorizes disclosure.”

6.4.6. Define Confidentiality Exceptions

It would be irresponsible to guarantee total confidentiality in a situation where there would be significant ongoing risk to safety. In the case of grossly negligent behavior, where the crew has “failed to exercise such care, skill or foresight as a reasonable man in his situation would exercise”, then action to prevent repetition should be agreed by a pre-defined group that would usually include crew representatives. Formal action may be required by law.

6.4.7. Inform Crew

At all times keep the crew informed of areas of concern and remedial actions contemplated. Their involvement and ideas will usually ensure a workable solution to operational problems that they have experienced and ensure future buy in to the programme.

6.4.8. Feedback on Good Airmanship

Where examples of good flying have been found then these should be highlighted and commented upon. They also make useful reference material when analyzing or debriefing less well executed flights.

Example: A well-flown go-around or procedurally correct TCAS resolution advisory action, with an ASR should be commended. Similarly, exceptional handling of technical problems may be singled out with data from the programme and used in training material.

Chapter 7 Interpretation and Use of FDA Information

7.1. Interpretation of Results - The Raw FDR Data

Interpretation and verification of the basic FDR data is a critical, if somewhat laborious, operation. The well known adage of "rubbish in - rubbish out" very much applies here.

7.1.1. Validation Checking Strategy

Most parameters required for the FDA programme are seen on every flight and these should be checked both by the program and visually. However, a number of parameters are rarely used except in more detailed analysis of incidents and these should be validated whenever the opportunity arises. There are also a number of rarely triggered warnings, operating modes etc. that can only be tested by complex procedures in the maintenance workshop. Reference to the validation and recertification of the mandatory crash recorder may assist in this process. A strategy outlining the frequency of checks and documenting "opportunity" checks during analysis should be laid down as part of the basic system maintenance procedures.

Examples of common use parameters: airspeed, altitude, air/ground switches, accelerations, flight controls, main auto-flight modes.

Examples of infrequently used parameters: alternate flap, less common auto-flight modes, GPWS and other warnings.

Examples of difficult to check parameters: hydraulic pressure warning; fire warnings, N1 over speed.

7.1.2. Watch for Bad Data, Datum Errors etc.

There are a range of basic data faults which can be either established – demanding changes in equipment or software, or transient such as a faulty transducer or processing unit.

Example of a Transducer Error: accelerometers occasionally stick and have an offset datum, say of 1.3g rather than 1.0g when at rest, or lose damping so they are over sensitive and hence reading too high.

Examples of Data Acquisition faults: One pitch angle sample each second does not follow the trend of the rest of the data. This can be caused by the system picking a sample from the previous second's data stream. Normal acceleration data can be filtered by passing through a system unit that removed high frequency data. Hence no heavy landing peaks.

7.1.3. Establish Characteristics of "Normal" Data

The essence of good interpretation is an ability to detect what is different or unusual. To do this the analyst must have knowledge of what “normal” data looks like and the variations that fall within a reasonable range.

Example of Parameter Characteristics: normal acceleration has a higher frequency content on the ground than on the air, has no stunted peaks, a 30 degree co-ordinated level turn should produce 1.15g and 45 degrees 1.4g.

Examples of a Normal Range of Parameters: pitch attitude should vary between say -10 and +25 degrees, speed on the approach should be between the stall speed and the flap limit speed +10 knots.

7.1.4. Cross-check Significant and Related Parameters

Where possible establish the technique of cross-checking between related parameters. For example, at rotation confirm pitch up is accompanied by an increase in normal acceleration, an elevator up control movement and is followed by the air/ ground switch moving to AIR.

Other Examples of Related Parameters: EPRs on engines normally are similar; heading changes with bank angle; opposing aileron deflections at turn initiation but the same sign during load relief or drooping with flap selection; positive longitudinal acceleration as ground speed increases.

	Time	Altitude	Airspeed	Heading	Vertical Acceleration	Pitch Attitude	Roll Attitude	Manual Mic Keying	Engine Thrust	Longitudinal Acceleration	Pitch Control Position	Lateral Control Position	Yaw Control Position	Pitch Control Surface	Lateral Control Surface	Yaw Control Surface	Lateral Acceleration	Pitch Trim Surface Position	Trailing Edge Flaps	Leading Edge Flaps Slats	Trust Reverse Position	Air Ground Sensing	Angel of Attack
(1) Time																							
(2) Altitude			√	√	√			√	√				√			√			√	√		√	
(3) Airspeed		√																√	√	√	√	√	
(5) Heading		√					√					√			√								
(4) Vertical Acceleration		√				√				√	√			√			√					√	
(7) Pitch Attitude					√						√			√				√					
(8) Roll Attitude				√											√		√						
(6) Press to Transmit for each transceiver		√																					
(9) Thrust of each engine		√																			√	√	
(11) Longitudinal Acceleration					√												√	√	√	√	√	√	
(18) Pitch Control Position					√	√								√				√					
(19) Roll Control Position				√			√								√								
(20) Yaw Control Surface Position		√														√							
(18)Pitch Control Surface Position					√	√					√							√					
(19) Roll Control Surface Position				√			√					√											
(20) Yaw Control Surface Position		√											√										
(16) Lateral Acceleration					√		√			√													
(17) Pitch trim			√			√				√				√									
(10) Trailing Edge Flaps		√	√							√									√				
(14) Leading Edge Devices stowed/deployed		√	√							√								√					
(13)Thrust Reverser stowed / deployed (each engine)			√						√	√												√	
(12) Undercarriage Squat of Tilt Switch		√	√		√				√	√											√		
(15) Angle of Attack						√					√												

Figure 3 Table Illustrating Parameter Correlation
Source: Table 2:20 Parameter Correlation – CASA Australia CAAP 42L-4(0): Flight Data Recorder Maintenance (October 2002

7.1.5. Relate Data to SOPs

Data and events should always be placed in the context of the operator's Standard Operating Procedures. It would be useful to annotate a typical flight with the SOP action points.

Examples of SOP Points Relevant to an Exceedance Program: the following speeds are used for configuration changes after take-off - at positive climb retract gear; above 35 ft AGL - autopilot on, speed not less than V2+10 or max pitch 18 degrees; at 1000 ft AGL select flaps up and set climb thrust.

7.1.6. Keep Examples for Future Training

Examples of good and bad data should be retained for use as training and familiarization material. Annotated "normal" traces can also be used as a yardstick against which to compare an incident/exceedances trace.

Examples of retained data: Significant incidents and unusual scenarios, Rejected Take-offs, GPWS reactions, exemplary cases where SOPs have been accurately followed, demonstrations of both good and bad techniques highlight the potential problems to crews.

7.2. Interpretation of Results - The Operational Assessment

During this part of the process the validated FDR data is assessed using knowledge of the operating environment and standards. It is here where the safety lessons will emerge and action decided upon.

7.2.1. Further Validity Checks

While most basic data errors should have been eliminated by this stage, more subtle data problems may still exist. In addition, where incidents seem inexplicable then errors in the data or in the program have been found to be present.

Examples of subtle errors: aircraft weight, parameter offsets, radio altimeter faults, airbrake lever arm position.

Examples of program errors: incorrect source of weight data taken, schedule speed reference table error, wrong event limits/specification.

7.2.2. Set Events in Context

Take-off and Approach events should be taken in the context of the physical and procedural characteristics of the particular airfield. During periods of bad weather, this also has to be taken into account.

Examples of airfield related context: location/local geography, altitude, runways, procedures including noise abatement, approach aids, ATC standards.

7.2.3. Correlation with Relevant Air Safety Reports

By this stage all events should have been correlated with relevant Air Safety Reports to give the best possible picture of these, normally more significant incidents. This will also prevent two separate investigations taking place into the same incident, each using only partial data. Normally, an interpreted summary of the FDR data should be added to the ASR investigation file and the follow-up controlled by the normal flight safety process within the operator's safety management system.

Examples of events normally covered by ASRs: GPWS stick shakes, loss of control, heavy landings etc. See CAA CAP 382 for details of the requirements laid down in the Air Navigation (General) Regulations 1993 Article 17.

7.2.4. The Need for Crew Debrief for Background Information

At an early stage in the assessment, a decision should be made if more information on the circumstances of the event should be obtained. In this case the confidential crew contact procedures should be initiated and the sooner they are contacted after the event the better their recollection will be. The timely correlation with any relevant ASRs will prevent wasted effort and duplication.

The information gathering objectives of such a debrief include learning of: ATC involvement, Weather, Technical problems, Procedural difficulties, Operational lapses, other traffic….

The training objectives may include: re-enforcement of SOPs, reminders of ASR requirements, congratulations for well handled emergencies such as a well flown windshear recovery.

Examples of cases benefiting from a confidential crew debrief: hurried approaches at busy airports, take-off rotation technique, unreported heavy landing, inappropriate autopilot mode use, SID technique, altitude busts…

7.2.5. Degree of Direct or Indirect Hazard

It is best if the degree of hazard is estimated to enable resources to be targeted at the most beneficial reduction in hazard. This may be to prevent a large number of relatively low risk events or to eliminate a low number of high risk events. In assessing the level of risk, the analyst must take into account both the direct risks and those that may be a consequence of those circumstances.

Example of a direct risk: a hard GPWS warning while an indirect one would be a plethora of false warnings - of little risk in themselves but if reducing the effectiveness of standard recovery from a real warning these could be catastrophic if not addressed.

7.2.6. Assess Potential Accident Factors

It is useful if a list of precursors of and causal factors in previous accidents is drawn up to further highlight potential hazards. These again may be relatively low risk events in their own right but good indications of the probability of further, more significant incidents.

Examples of accident precursors: positional errors, auto vs manual flight conflict, landing technique, directional control during take-off and landing runs.

7.2.7. Assess Frequency - Single Event or Systematic Problem

The events should be assessed in the context of previous experience. One of a series showing a trend or a one-off incident in exceptional circumstances. Clusters of events may occur at a particular airfield, on one aircraft or during a period of bad weather. By placing all events on a database will enable the analyst to decide an informed course of action.

7.2.8. Taking Action - The Decision Process

As with any safety report, the responsible analyst must decide if it is appropriate to take action to prevent repetition. Action could be required due to safety severity (through individual risk or high frequency), financial or operational implications. Actions and the underlying reasons and data used should be recorded to provide an audit path.

7.2.9. Continuous Analysis of Result of Actions

After taking action, anticipated knock-on effects should be carefully monitored to ensure no risks are transferred elsewhere. A general monitor should also be applied to pick up other changes.

Chapter 8 Legislation and Requirements Related to FDA

This chapter summarizes some of the legislation and requirements that surround the area of FDA including the recently agreed ICAO recommendation and standard for flight data analysis.

NOTE: The selected text from such requirements is shown below, boxed for clarity.

8.1. Accident Prevention and Flight Safety Programmes

ICAO Annex 6, Part 1, International Commercial Air Transport – Aero planes 3.6.1 requires that "an operator shall establish and maintain an accident prevention and flight safety programme." The ICAO Amendments to Annex 6 that specify new provisions pertaining to flight data analysis programmes are detailed. Guidance is contained in the Accident Prevention Manual (Doc 9422), ICAO Accident Prevention Programme Manual (Ed. 2005) and Preparation of an Operations Manual (Doc 9376).

8.1.1. Guidance material for the establishment of a safety programme can be found in:

a. ICAO Doc 9422 (Accident Prevention Manual);

b. ICAO Accident Prevention Programme Manual (Ed. 2005) ; and

c. ICAO Doc 9376 (Preparation of an Operational Manual).

8.1.2. ICAO Annex 6 Part 1 – Amendment 26 Flight Data Analysis

The following amendment, to include Flight Data Analysis as part of every operator's accident prevention and flight safety programme, was adopted during 2001. Note that the 2002 date is a recommendation for aeroplanes over 20,000 kg whereas the 2005 date is an international standard and as such will be adopted as a formal requirement by most member states. The reader should also note that this applies to aeroplanes over 27,000 kg i.e. mandatory on the larger aircraft and recommended on the smaller ones. A list of typical types covered by these requirements is given in **Appendix E.**

8.1.3. ICAO Annex 6 Part 1 - CHAPTER 3. GENERAL

3.2 Accident prevention and safety programme

3.2.1 An operator shall establish and maintain an accident prevention and flight safety programme.

3.2.2 Recommendation. – From 1 January 2002, an operator of an aeroplane of a certificated take-off mass in excess of 20,000kg should establish and maintain a flight data analysis programme as part of its accident prevention and flight safety programme.

3.2.3 From 1 January 2005 , an operator of an aeroplane of a certificated take-off mass in excess of 27,000kg shall establish and maintain a flight data analysis programme as part of its accident prevention and flight safety programme.

Note.- *An operator may contract the operation of a flight data analysis programme to another party while retaining the overall responsibility for the maintenance of such a programme*.

3.2.4 A flight data analysis programme shall be non-punitive and contain safeguards to protect the source(s) of the data.

8.1.4. ICAO Annex 13 – CHAPTER 5. INVESTIGATION

Flight Recorders – Accidents and Incidents

5.7. Effective use shall be made of flight recorders in the investigation of an accident or incident. The state conducting the investigation shall arrange for the read –out of the flight recorders without delay.

5.8 **Recommendation** - In the event that the State conducting the investigation of an accident or an incident does not have adequate facilities to read out the flight recorders, it should use the facilities made available to it by other states, giving consideration to the following:

a) the capabilities of the read-out facilities
b) the timeliness of the read-out; and
c) the location of the read-out facility

***Note**: The requirements for recording of radar data and ATS communications are contained in Annex 11, Chapter 6.*

5.16 When an aircraft involved in an accident or a serious incident lands in a state of the operator shall, on request from the state conducting the investigation, furnish the latter state with the flight recorder records and if necessary, the associated flight recorders.

***Note:** In implementing 5.16, the state of Registry or the State of Operator may request the corporation of any other state in the retrieval of the flight recorder records.*

8.1.5. Preservation, production and use of flight recorder recordings - (Reference JAR-OPS 1.160)

(a) Preservation of recordings

(1) Following an accident, the operator of an aeroplane on which a flight recorder is carried shall, to the extent possible, preserve the original recorded data pertaining to that accident, as retained by the recorder for a period of 60 days unless otherwise directed by the investigating authority.

(2) Unless prior permission has been granted by the Authority, following an incident that is subject to mandatory reporting, the operator of an aeroplane on which a flight recorder is carried shall, to the extent possible, preserve the original recorded data pertaining to that incident, as retained by the recorder for a period of 60 days unless otherwise directed by the investigating authority.

(c) Use of recordings (Reference JAR-OPS 1.160)

(1) The cockpit voice recorder recordings may not be used for purposes other than for the investigation of an accident or incident subject to mandatory reporting except with the consent of all crew members concerned.

(2) The flight data recorder recordings may not be used for purposes other than for the investigation of an accident or incident subject to mandatory reporting except when such records are:

(i) Used by the operator for airworthiness or maintenance purposes only; or

(ii) De-identified; or

(iii) Disclosed under secure procedures.

8.2. Requirements – Mandatory Occurrence Reporting Scheme

This means that information obtained by an operator when analyzing the flight data collected on one of its flights may well reveal an incident that is required to be reported to the CAA under the Mandatory Occurrence Reporting Scheme (as per the Annex 13, Chapter 8). The implications are discussed in Chapter 10.

8.3. Requirements Carriage of FDR

The requirements for carriage of FDR are contained in ASN 053. The operational performance requirements for Flight Data Recorders are laid down in ICAO Annex 6 (Operation of Aircraft). The requirements of Flight Data Analysis Programme and Flight Safety Documentation System are contained in ASN 073 and ASN 074 consequently.

8.4. Requirements - FDR Engineering Data Decoding Specification

International efforts are being made to ensure that the information required for reliable decoding for accident investigation is properly retained by all operators. Additional information is available in **Appendix F.**

Chapter 9 Legislation Related to FDA Information

This chapter explores the interaction of the FDA process, actions taken by the operator and the information that FDA produces with underlying law. Much of this area has yet to be tested legally and the information given here is only a discussion of the possible interactions and should be regarded only as a guide to the subject area. **For definitive information specialist legal advice should be sought.**

As with all safety related information, but more particularly the automatically generated FDA exceedences events, secure and confidential processing and promises of protection from punishment are important. However, any protection or identification of individuals and companies has to remain within the current legal framework.

It is important to note that FDA data should be regarded as impartial in any set of circumstances. It can prove “innocence” or confirm “guilt”. It can help prove that an operator has taken all reasonable steps to prevent passenger injury – say in the case of seat belt signs being on during turbulence – or that the continued degraded autopilot performance should have been acted upon earlier.

9.1. Legal Responsibility for Conduct

It is important to recognize the limitations placed on the conduct of aviation professionals by the law, in particular, the criminal offence of endangering due to **reckless** or **negligent** behavior. These need to be understood when constructing the protective agreements in FDA programmes – referred to in Chapter 10 and **Appendix B**. These should take into the account the potential implications of these very rare situations.

A high percentage of accidents are said to be due to pilot error. Accidents are however rarely caused by a single factor, usually many things have "gone wrong". Although it may be that the pilot's reaction to the final event is found wanting, it may not be accurate to ascribe the crash solely to this.

Aviation professionals, such as pilots, operations or certification managers are not expected to be superhuman beings. It must therefore be accepted that they will make mistakes. Accidents do happen even when the professional has acted entirely properly. If however it can be proved that the professional has made an error that amounts to negligence, they may be liable to criminal prosecution action. If they have displayed a lack of competence, the regulator may take licensing action. They may also be subject to disciplinary action by the employer. Finally, they may be liable to a civil claim for damages from, for example, a passenger injured in a resulting accident.

9.1.1. Legal Terms - Endangering

In addition to the specific offences contained in Regulations e.g. low flying, flying with unserviceable equipment, flying an aircraft without a certificate of release to service, there are two general offences which are likely to be relevant in the event of an aircraft accident or incident. First, it is an offence for a person to “recklessly or negligently act in a manner likely to endanger an aircraft or any person therein”. Secondly, “a person shall not recklessly or negligently cause or permit an aircraft to endanger any person or property.”

9.1.2. Legal Terms - Recklessness

A reckless act is one which a normal person would realize would have harmful consequences. If an individual could be expected to have realized that the likelihood of such harmful consequences was not negligible, yet still went on to act, then they would be culpable.

9.1.3. Legal Terms - Negligence

A person is negligent if he fails to exercise such care, skill or foresight as a reasonable man in his situation would exercise.

Because "human factors" is so obviously a multi-factorial concept, it makes the attribution of legal responsibility that much harder. The judgement call faced by lawyers and litigants, as to whether a person has acted recklessly or negligently, when a professional man has made an error of judgement, is very difficult and there seems to be wide divergences of opinion.

9.2. Human Rights Acts and Legal Discovery

The aviation professional may be concerned that FDA data is being collected and analyzed and may result in action being taken against them. Several decades of UK experience in fact shows that pilots are several times more likely to be involved in a Reportable Accident than face disciplinary action as the result of FDA. In practice, with well-devised organization and control of the FDA process, the aviation professional should be reassured. This section examines some of the legal issues surrounding the retention of FDA data that helps minimize the potential for unwarranted intrusion on the individual.

9.2.1. De-identifying and Destruction of Information

It is permissible to have a general policy regarding destruction of information. In some cases there are statutory limitations as to how long data should be retained. Otherwise it is a question of what is reasonable.

9.2.2. Retaining and Preserving Documents/Records for Court Proceedings

Once commencement of civil litigation, to which you are a party, appears likely, you cannot destroy any information relevant to the litigation, or potential litigation, held/ controlled by you and to do so is contempt of court. Disclosure requires you to allow the other parties in the litigation access to all those documents and computer records in your control that are relevant to the issues in the action (unless the documents/ records are privileged). De-identified documents need not be made identifiable. However, if the identity of, for example, the flight crew-member concerned is relevant, the court may order that you also disclose those documents/records which enable identification to be made.

It is also possible for the Police to obtain court orders requiring access to FDA data when investigating a suspected criminal offence. If the case did not proceed then this data should be considered confidential and not disclosed. A potential civil litigant can sometimes persuade a court to order disclosure of apparently relevant information prior to commencing legal proceedings. “Fishing expeditions” to try and discover if a case exists rather than to support a particular case are not permitted.

Once litigation is contemplated you cannot proceed to ‘amend’ documents by de-identifying them. Again this would be contempt of court. You also cannot destroy any relevant material, even if to do so would otherwise be in accordance with your normal say for example - **X** month destruction period.

However, recipients of your documents/records i.e. other parties to proceedings, can only use that information in those particular proceedings. You are entitled to ask for copies back at the end of proceedings and seek an injunction if information is used for any other purposes. Nevertheless, in cases where information is commercially sensitive and the other parties to the proceedings are competitors, the damage may already have been done.

Destroying evidence of a criminal offence can be an attempt to pervert the course of justice. However, until a person has been made aware that a criminal offence is being, or is likely to be investigated it might be considered unreasonable to expect retention --of information that will be needed for evidence.

If the CAA is conducting a prosecution, in theory it can also ask the court to order that certain information be produced to the CAA. However, the court would have to have strong evidence, from other sources, that an offence had been committed before it is likely that a court would exercise its discretion to make an order in this way.

9.3. The Need to Take Reasonable Action on Information Held

Industry should not collect data that it does not then use. If it became apparent that the analysis of data, which had been collected and held, would have alerted an operator to a problem before an incident/accident occurred, it could be argued the operator is liable for the result of failing to conduct that analysis and act upon the results.

Chapter 10 Mandatory Occurrence Reporting and FDA

This chapter deals with the practical issues arising when FDA information is used in the follow-up process.

Once it has been ascertained that there is significant actual or potential risk associated with an issue raised by **any** safety Analysis process then it is widely accepted that there is an obligation to

(a) act upon it to prevent a repetition;
and
(b) spread the safety message both within the company and to industry to prevent "someone else's accident".

After recording and acting upon such information as an Air Safety Report (ASR) within the company then the principal medium for broadcast to UK industry is the Mandatory Occurrence Reporting Scheme (MORS). It is logical to feed the lessons obtained from FDA into this existing and trusted system.

10.1. Air Safety Reports and Mandatory Occurrence Reporting

10.1.1. Air Safety Reports (ASRs)

The incident reports initially submitted to the operator's flight safety officer are often referred to as Air Safety Reports (ASRs). The processing, assessment and actions arising from each ASR will form part of the operator's Safety Management System. ASRs are raised by a wide range of methods and triggers. A flight crew or air traffic controller's assessment of a risk, the result of an engineer's inspection, cabin crew reports, security staff etc. all contribute to an overall awareness of the safety risk to the operation. Be aware that an incident may be reported in one or more reporting systems e.g. ground report, maintenance, human factors, cabin crew etc. and that an integrated system will bring together all the relevant information. Reports could indicate failure of the defensive measures you have put in place to prevent a hazard.

10.1.2. Mandatory Occurrence Reports (MORs)

The more significant ASRs (along with maintenance and other reports) will be noted, either by the person submitting the report or the safety officer, as requiring submission to the CAA's MOR Scheme. These reports are further considered, acted upon and publicized to increase awareness.

10.1.3. Retention of FDR data for MORs

CAASL Mandatory Occurrence Reporting Scheme, gives the following advice;

After an incident, a quick judgement has to be made as to whether FDR data is likely to be useful in an investigation. The short recycling/overwriting time of most FDRs makes it critical that a decision to quarantine the data is taken very rapidly. Experience shows that this is a very difficult requirement to fulfill. Where QAR data is available it is suggested that operators may wish to approach the CAA with a proposal to substitute QAR data for that from the FDR.

10.1.4. Confidentiality Issues

While all ASRs are attributable to the reporter, an open safety reporting culture relies on the knowledge that the identification of individuals is restricted to a need-to-know basis and that it is definitely non-punitive.

It should be noted that there is a difference between anonymity and confidentiality with the former being less desirable in an integrated safety system. While the reports generated automatically from FDA programmes should be treated confidentially, the greatest benefit will be gained by correlating this information with other relevant safety and technical reports especially in the case of the most hazardous or significant events. Where an air safety report has already been submitted then (only) relevant FDA events can be used to add to the understanding of the circumstances of the incident. It is important to emphasize that it is not the purpose of the process to check out the reporter's recollection and accuracy.

10.1.5. Withdrawal of Protection of Identity

Experience has shown that very rarely there will be cases where an important issue has been raised by FDA and for some reason no report has been submitted. In this case the persons involved have been encouraged, through a confidential contact by a crew representative or other trusted person, to submit, "without prejudice", a report. This method of contact has proved to be very effective in soliciting reports and a good means of imparting constructive safety advice to those involved. Almost invariably any advice or remedial action, i.e. training, is well received by the crews – on the understanding that this is not "held against them".

In the **extremely** rare case where **there is a definite ongoing safety risk** and no report is forthcoming despite requests, making remedial action impossible, then agreed procedures are followed to allow essential safety action to be taken. It should be emphasized that at no stage in this process is disciplinary action considered. There may have to be a judgement made on the probability of recurrence against a potential reduction in the openness of the overall safety culture resulting from a loss of confidence. However, experience has shown that the vast majority of FDA information is concerned with lower levels of hazard where no identification is needed.

10.1.6. Confidentiality and Mandatory Occurrence Reports

It should be noted that while MORs are not subject to FDA confidentiality agreements, it is possible to submit a confidential MOR. In this way, although the original report must be identified, this information will be restricted during subsequent publication and analysis.:

10.2. FDA and Mandatory Occurrence Reporting

Within a good safety culture the vast majority of significant Individual FDA events/ exceedances will be the subject of crew air safety or occurrence reports and investigations. This section considers the interaction of FDA information and the MOR system.

10.2.1. Reporting Standards and Audit Events

FDA systems have proven to be very effective in reminding crews to submit reports during the early stages and are then a useful audit tool, confirming reporting standards in an established programme. Issues covered may include the following:

- Various warnings: Stall, Hard GPWS, high speed or major systems warning
- Heavy landing
- Tailscrape
- Rejected take-off at high speed and go-arounds
- Engine failure
- Severe turbulence and vortex wake encounters
- Altitude deviation
- Flight control difficulties indicated by excessive/untypical control deflections

It should be remembered that in the case of significant incidents found as the result of FDA analysis, the crews should be encouraged to submit retrospective reports - without prejudice or penalty to the crew concerned.

10.2.2. Reporting of Issues raised by FDA Events

It would only be in cases of general underlying trends and wider issues when FDA data alone would be used to raise ASRs or MORs.

Multiple FDA events may come together to indicate a potential issue for wider consideration or action. Examples of the type of issue that would be appropriate for such a submission include:

- Unacceptable number of Unstabilized/rushed approaches at a particular airfield.
- False/nuisance GPWS warnings at a particular location or with certain equipment.
- Rough Runway – permanent problem area or out of Specification temporary ramps.
- Repeated near tailscrapes due to pilot rotation technique indicating revised guidance required.
- Repeated events considered unacceptable elsewhere produced by a particular SID.
- Reduced fuel reserves on certain sectors.

Chapter 11 Maintaining Aircraft FDA Systems

This chapter deals with the requirements for the maintenance of FDA systems subsequent to the introduction of the FDA requirements. In the case of QARs and other equipment this has, until now, not been formally required and so has been fitted on a "No Hazard" basis without implications on the minimum equipment requirements for dispatch.

The new requirements for FDA will apply an additional mandate to the carriage and intended usage of the Flight Data Recorder system that the original design and certification assumptions may have not taken into account.

When operators make operational and maintenance decisions based on data additional to that mandated for accident investigation purposes, it is important that the validity of the data on which they are based and the reliability of the recording devices are assured by applicable and effective scheduled maintenance instructions and procedures.

11.1. Equipment Specification

The equipment that operators propose to use for FDA should be acceptable to the CAASL. This equipment should be maintained to an agreed schedule that will meet these requirements.

Clarification of what are mandatory FDR parameters is in Attachment D to Annex 6 Part 1 as are the maintenance practices to assure recorder serviceability.

11.2. Maintaining Equipment Performance

The maintenance tasks required to ensure the continued serviceability of the installed flight recorder system will depend on the extent of Analysis built into the recorder and its sensors. The system installer will need to perform an analysis of the system to identify those parts of the system which, if defective would not be readily apparent to the flight crew or maintenance personnel. Appropriate inspections and functional checks, together with the intervals at which these would need to be performed, will need to be established as indicated by the analysis. This philosophy should be applied to recoding systems used for FDA.

Air operators must preserve a record of one representative flight made within the last 12 months. The purpose of this is to ensure that, in the event of an accident/incident, air accident investigators have access to a readout from the flight data recording system that is representative of the actual aircraft condition prior to the accident/incident. It follows that the data originating from the selected representative flight will need to be evaluated to determine that it comprises a valid record."

While it is not mandatory to use this data for the evaluation of FDR serviceability, it is recommended that operators do this, as it is an effective method of confirming compliance.

The validity of recorded data provides evidence of the FDR system performance in a flight dynamic situation that cannot be achieved during ground testing alone. FDR readouts in general, can be utilized to evaluate FDR serviceability. It is recommended that when the mandatory recorder calibration checks are carried out, a parallel check is made to confirm the validity of any other recording equipment such as QARs.

11.3. QAR Serviceability and MELs

When considering an inoperative QAR or equivalent data system, the associated MEL conditions are dependent upon the criticality of the uses to which the data is put.

Appendix A

Typical FDA Exceedance Detection and Routine Parameter Analysis

1. Traditional Basic Operational Event Set

These operational events are typical of those found in most current FDA programs. There have been minor developments over the past 20 years but are basically the same as developed programme during the late 1970's. However, they still form an excellent starting point for any Analysis programme. (Refer to Chapter 5 Para 5.9.4)

Event Group	Event Code	Description
Flight Manual Speed Limits	01A	Vmo Exceedence
	02A	Mmo Exceedence
	03A	Flap placard speed exceedence
	03G	Gear down speed exceedence
	03I	Gear up/down selected speed exceedence
Flight Manual Altitude Limits	04	Exceedence of flap/slat altitude
	05	Exceedence of maximum operating altitude
High Approach Speeds	06A	Approach speed high within 90 sec of touchdown
	06B	Approach speed high below 500 ft AAL
	06C	Approach speed high below 50 ft AGL
Low Approach Speed	07A	Approach speed low within 2 minutes of touchdown
High Climb-out Speeds	08A	Climb out speed high below 400 ft AA L
	08B	Climb out speed high 400 ft AAL to 1000 ft AA L
Low Climb-out Speeds	08C	Climb out speed low 35 ft AGL to 400 ft AAL
	08D	Climb out speed low 400 ft AAL to 1500 ft AAL
Take-off Pitch	09A	Pitch rate high on take-off
Unstick Speeds	10A	Unstick speed high
	10B	Unstick speed low
Pitch	20A	Pitch attitude high during take-off
	20B	Abnormal pitch landing (high)
	20C	Abnormal pitch landing (low)

Event Group	Event Code	Description
Bank Angles	21A	Excessive bank below 100 ft AGL
	21B	Excessive bank 100 ft AGL to 500 ft AAL
	21C	Excessive bank above 500 ft AGL
	21D	Excessive bank near ground (below 20 ft AGL)
Height Loss in Climb-out	22D	Initial climb height loss 20 ft AGL to 400 ft AAL
	22E	Initial climb height loss 400 ft to 1500 ft AAL
Slow Climb-out	22F	Excessive time to 1000 ft AAL after take-off
High Rate of Descent	22G	High rate of descent below 2000 ft AGL
Normal Acceleration	23A	High normal acceleration on ground
	23B	High normal acceleration in flight flaps up/down
	23C	High normal acceleration at landing
	23D	Normal acceleration; hard bounced landing
Low go-around	024	Go-around below 1000 ft AAL
High go-around	24A	Go-around above 1000 ft AAL
RTO	026	High Speed Rejected take-off
Configuration	40C	Abnormal configuration; speed brake with flap
Low Approach	042	Low on approach
Configuration	43A	Speedbrake on approach below 800 ft AAL
	43B	Speedbrake not armed below 800 ft AAL (any flap)
Ground Proximity Warning	44A	GPWS operation - hard warning
	44B	GPWS operation - soft warning
	44C	GPWS operation - false warning
	44D	GPWS operation - windshear warning
Margin to Stall	45A	Reduced lift margin except near ground
	45B	Reduced lift margin at take-off
	46A	Stickshake
	46B	False stickshake
Configuration	047	Early configuration change after take-off (flap)

Event Group	Event Code	Description
Landing Flap	48A	Late land flap (not in position below 500 ft AAL)
	48B	Reduced flap landing
	48D	Flap load relief system operation
Glide slope	56A	Deviation under glide slope
	56B	Deviation above glide slope (below 600 ft AGL)
Buffet Margin	061	Low buffet margin (above 20,000 ft)
Approach Power	75A	Low power on approach

2. Extended Operational Event Set

In addition to the basic events detailed above, there are a number of new events that could be used to detect other situations that an operator may be interested in. Some of the new triggers are relatively simple to implement while others would need careful coding and research to avoid false events while still activating against good data. (refer to Chapter 5 paragraph 5.9.6)

Description	Notes
Engine parameter exceedence (e.g. TGT etc.)	One of a range of engine monitors.
Full and free control checks not carried out	Essential pilot actions and measure of control transducers.
Taxi out to take-off time - more than (x) minutes	Can be measured against a standard time for that airfield and runway.
High Normal Acceleration - Rough taxi-way	Record an estimate of position derived from Ground speed and heading.
High Longitudinal Acceleration – Heavy braking	as above
Excessive Taxi Speed	as above
Take-off configuration warning	
Landing gear in transit longer than (x) seconds	To be used as an indicator of system problems and wear.
Flap/slats in transit longer than (x) seconds	as above
Master Warning	All master warnings, even if false, heard by the crew are a useful indicator of distractions and "mundane/known problems".
Engine failure	To confirm efficacy of crew training and assist any technical investigation.

Description	Notes
Autopilot vertical speed mode selected below (x) ft	One of a range of auto flight system usage monitors.
Fuel Remaining at landing below minimums	
Airborne holding - more than (x) minutes	Pin-points large holding delays.
Excessive control movement - airborne(especially rudder)	This will indicate control problems that other events might not identify.
TCAS warning	A must for Analysis future significant hazards and crew reactions.
Landing to shutdown time - more than (x)	Indicates taxiway or stand allocation problems.
Auto ground-spoiler not selected for landing	
Localizer deviation	Excessive or oscillating.
Altitude déviation	Level busts, prématuré descents etc.

3. Operational Parameter Analysis Variables

The following list suggests additional parameters that could be extracted from each flight and logged into a database. The concept is to log a sufficiently wide range of data points from each flight so as to enable the analyst to deduce and compare performance and safety measures. Airfield, runway, weight, time of year and many other combinations of circumstances may be correlated.

This approach to FDA has proved very useful in determining what is normal as opposed to the event method that gives what is abnormal. (refer to Chapter 5 paragraph 7.7)

Subject Area	Description
General	Arrival and Departure time, airfield and runway *note the identification of date is normally limited to month to restrict identification
	Temperature, pressure altitude, weight, take-off/landing Configuration
	Estimated wind speed - headwind and crosswind components
	Aircraft Routing - reporting points and airways
	Cruise levels
	Elapsed times - taxi-out, holding, climb, cruise, descent and approach, taxi in.

Power plant	Start up EGT etc.
	Max power during take-off
	Cruise performance measure
	Reverse thrust usage, time, max-min speeds, thrust setting
Structures	Flap/slat configuration vs time usage
	Flap/slat configuration vs max normal acceleration
	Flap/slat configuration vs normal acceleration max/min counter
	Flap/slat - Asymmetric deployment
	Airbrake extension - time, max and min speeds
	Gear extension/retraction cycle times
	Aircraft weight at all loading event times
	Landing assessment - pitch and roll angles and rates (plus other parameters)
	Normal acceleration at touchdown
	Normal acceleration - Airborne - Count of g crossings
	Normal acceleration - Ground - Count of g crossings
Subject Area	**Description**
Flight Operations	Take-off and landing weight
	Thrust setting at take-off
	Rotation speed
	Lift-off speed and attitude
	Climb out speeds
	Climb height profile
	Noise abatement power reduction - height, time etc.
	Flap speeds - selection, max, min

	Gear speeds - selection, max, min
	Top of Descent point - time to landing
	Holding time
	Autopilot mode usage vs altitude
	Approach flap selection - time, speed, height
	Glideslope capture point - time, speed, height
	Localiser capture point - time, speed, height
	Maximum control deflection - airborne
	Maximum control deflection - ground
	Maximum control deflection - take-off or landing roll
	Landing speeds, attitudes and rates
	Turbulence indication - climb, cruise, descent and approach
FDR Data Quality	Periods of bad/poor data
	Percentage of airborne data not analyzed
	Take-off or landing not analyzed
	Bad/non-existent FDR parameters
Subject Area	**Description**
Fuel Usage	Take-off fuel and Landing fuel
	Taxi-out fuel burn
	Taxi-in fuel burn
	Total fuel burn
	Reserve fuel
	Specific fuel burn
	fuel burn measurement

Appendix B

Sample Memorandum of Understanding for the Operation of a Flight Data Analysis (FDA) Programme between an Airline and a Pilot Association

1. Background

1.1 The Flight Data Analysis Programme, FDA PROGRAMME, forms part of THE AIR LINE's Safety Management System. Recorded Flight Data can contain information that has the potential to improve flight safety, but also has the potential, if used inappropriately, to be detrimental to individual crewmembers or to the airline as whole. This document describes protocols that will enable the greatest safety benefit to be obtained from the data whilst satisfying the company's need to be seen to be managing safety, and simultaneously ensuring fair treatment of employees.

The FDA PROGRAMME conforms with the intent of THE AIRLINE's Standing Instruction number X (SIN X), Reporting of Safety Incidents, in that "The purpose of an investigation of any accident or incident is to establish the facts and cause, and therefore prevent further occurrence. The purpose is not to apportion blame or liability."

It also conforms with the intent of ICAO Annex 6 (Part1, Chapter 3)" A Flight data analysis programme shall be non-punitive and contain safeguards to protect the source(s) of the data.

2. General Intention

2.1 It has long been accepted by both THE AIRLINE and THE PILOTS ASSOCIATION that the greatest benefit will be derived from the FDA PROGRAMME by working in a spirit of mutual corporation towards improving flight safety .A rigid set of rules can, on occasions, be obstructive, limiting or counter-productive, and it is preferred that those involved in the FDA PROGRAMME should be free to explore new avenues by mutual consent, always bearing in mind that the FDA PROGRAMME is as safety programme, not a disciplinary one. The absence of rigid rules means that the continued success of the FDA PROGRAMME depends on mutual trust- indeed this has always been a key feature of the programme.

2.2 The primary purpose of monitoring operational flight data by the FDA PROGRAMME is to enhance flight safety. Therefore the intention of any remedial action following discovery, through the FDA PROGRAMME is to enhance flight safety. Therefore the intention of any remedial action following discovery, through the FDA PROGRAMME, of a concern, is to learn as much as possible in order:

a) To prevent a recurrence; and
b) To add to our general operational knowledge.

2.3 A general Intention is that concerns raised by the FDA PROGRAMME should, where possible, be resolved without identifying the crew concerned.

However there may be occasions when anonymity is not appropriate, and this document gives protocols to be followed on such occasions in order to be in accordance with SIN X.

2.4 It is recognized that THE AIRLINE requires an audit trail of actions taken following FDA PTOGRAMME investigations. It is intended that this audit trail will beheld within THE AIRLINE in a manner that satisfies THE AIRLINE's requirements without being placed on a crewmember' s file.

2.5 A further intention is to provide recorded flight data to outside parties (CAA, FAA, Universities, manufacturers, etc.) for research into flight safety. THE PIULOTS ASSOCIATION will be informed of each such provision and, if the data is only useful if identified (i.e. can be linked to a specific flight) then THE AIRLINE will agree with THE PILOTS ASSOCIATION the confidentially terms under which the data is provided.

3. Constitution

3.1 The constitution and responsibilities of the Flight data-recording group (the "FDA PROGRAMME Group) are defined in FOC Y. The Group meets once a month. Membership consist of;

The Chairman (Flight Manager FDA Programme) A representative from each Fleet's training section A representative from Flight Data Recording (Engineering) A representative from Flight Technical Support A Flight Data Analysist from Flight Operations Representatives from the PILOT ASSOCIATION(currently two short-haul representatives and one long-haul representative)

3.2 The constitution and responsibilities of the Operational Flight Data Recording Working Group are defined in FCO Y. The Group meets bimonthly. Membership consist of;

The Chairman (Flight Manager FDA Programme) A Flight Data Analysist from Flight Operations Manager Flight Data Recording (Engineering) A representative from Flight Technical Support A representative from Safety Services A representative from CAA Safety Group Representatives from the PILOT ASSOCIATION

4. Handling

4.1 Scope

This section applies to "events" discovered by the routine running of the FDA PROGRAMME. If a pilot files an Air Safety Report or reports an event to his Manager, then the responsibility for investigation lies with the Fleet, although the FDA PROGRAMME group may provide assistance. In the case the pilot is, of course ,identified.

4.2 The list below gives some of the possible follow-up actions that may be used to investigate a concern raised by the FDA PROGRAMME. It is not intended to be exhaustive and does not preclude any other action agreed between THEAIRLINE and THE PILOTS ASSOCIATION, which is in accordance with the general intentions above.

Which action is most appropriate in given circumstances will be discussed and agreed between THE AIRLINE, represented by Flight Manager FDA PROGRAMME and the Fleet FDA Programme representative, and THE PILOTS ASSOCIATION, represented by the relevant PILOTS ASSOCIATION representative.

A Fleet Manager may request follow-up action. He will make his request to his Fleet FDA Programme and the relevant PILOTS ASSOCIATION representative, as above.

4.2.1 THE PILOTS ASSOCIATION may be asked to telephone the crewmembers to debrief an "event". The nature of the call can be praise for a well-handled situation, enquiry to elicit more information about the event and its causes, or a reminder of a relevant Standard Operating Procedure.

The Fleet management may ask for specific questions or points to be put to the pilots during such a call or calls.

In this case the pilots remain unidentified, and a record of the debriefing will be held in accordance with section 5 of this agreement.

4.2.2 THE PILOTS ASSOCIATION may be asked to contact a pilot who has a higher than average FDA PRIGRAMME event rate, to advice the pilot and to seek any underlying reason. Again, Fleet management may ask for specific questions or points to be put to the pilots during such a call or calls. In this case too, the pilots remain unidentified, and a record of the debriefing will be held in accordance with section 5 of this agreement.

4.2.3 The inquiries of paragraphs 4.2.1 and 4.2.2 above may indicate that " closure" may not be possible without further action being taken. The following are examples of possible further action:

- The filling of ASR – see paragraph 4.2.4 below;
- A request for the pilot to speak directly to Fleet management – see paragraph 4.2.5 below; and
- A requirement for the pilot to undertake some training to regain the required standard in a particular area – see paragraph 4.2.6 below

4.2.4 If the "event" clearly warrants an ASR, but none has been filed, then THE PILOTS ASSOCIATION may be asked to request that the pilot(s) files one. An ASR field under these circumstances will be treated as if it was filed at the time of the event.

4.2.5 THE PILOTS ASSOCIATION may be asked to invite a pilot to be debriefed by his Fleet management. If the pilot agrees to this, then he will be deemed to have reported the event unprompted so that paragraph 10.1 of SIN X applies: "it is not normally the policy of THE AIRLINE to institute disciplinary proceedings in response to the reporting of any incident affecting air safety."

A record of any such debriefing will be sent to the pilot concerned and a copy held in THE AIRLINE in accordance with section 5 of this document.

If the pilot declines the above invitation, then THE PILOTS ASSOCIATION debriefing will be continued until closure can be achieved. A record of this debriefing will be kept in accordance with section 5 of this document.

4.2.6 A pilot may be required to undertake such extra training as may be deemed necessary after consultation with the fleet concerned. THE AIR LINE will arrange the training, and THE PILOTS ASSOCIATION will liaise with the pilot.

4.3 If an event or sequence of events is considered serious enough to have hazarded the aircraft or its occupants, then THE PILOTS ASSOCIATION will be asked to withdraw anonymity of the pilots. THE PILOTS ASSOCIATION recognizes that, in the interest of flight safety, it cannot condone unreasonable, negligent or dangerous pilot behavior and will normally accede to such a request.

Removal of anonymity will be effected by the senior PILOTS ASSOCIATION representative after consultation with THE PILOTS ASSOCIATION chairman. The pilot will be notified by the senior PILOTS ASSOCIATION representative that anonymity is being withdrawn, and advised that he or she may be accompanied at any subsequent interview by a PILOTS ASSOCIATION representative.

If agreement cannot be reached between THE AIRLINE Flight Operations and THE PILOTS ASSOCIATION as to whether an event is sufficiently serious to warrant withdrawal of anonymity, then a final decision will be taken by a nominated person. This person will be either THE AIRLINE head of safety or another nominated senior AIRLINE Manager, and he /she will be confirmed in this role by THE PILOTS ASSOCIATION who will reaffirm this acceptability each year.

4.4 Willful disregard of SOPs

If a pilot is discovered, through the FDA PROGRAMME only, to have willfully disregarded THE AIRLINE SOPs, then he will be treated as follows:

If the breach of SOP did not endanger the aircraft or its occupants, then debriefing may be carried out by THE PILOTS ASSOCIATION representative, thus preserving anonymity; but the pilot will be sent a letter containing a clear warning that a second offence will result in withdrawal of anonymity.

If the breach of SOP did endanger the aircraft or its occupants, then THE AIRLINE will request withdrawal of anonymity as in paragraph 4.3 above.

4.5 If a pilot fails to corporate with THE PILOTS ASSOCIATION with regard to the provisions of this agreement, then THE AIRLINE will receive THE PILOTS ASSOCIATION approval to assume responsibility for contact with that pilot, and any subsequent action.

Such a pilot will be reminded by THE PILOTS ASSOCIATION that SIN X cautions: " In the event of an employee failing to report a safety related incident that they have caused or discovered, they will be exposed to full disciplinary action."

5. Closure

5.1 Most FDA PRIGRAMME events are not serious enough to warrant follow-up action and so are automatically "closed" . Those events for which follow-up action is required are deemed "open", and then need a positive closure when the action is complete.

5.2 A record will be kept in the AIRLINE of all events for which action is required . For each such event, the actions taken will be recorded along with a date of closure. This record will be kept in the FDA PROGRAMME database against the event itself.

No record will be kept on an individual pilot's file.

5.3 A letter will be sent, by Fleet Management, to each pilot involved in follow-up action, unless that action consisted only of a telephone debriefing by THE PILOTS ASSOCIATION representative for a single event. Such a letter will record the original concern, the subsequent discussion and/ or action, and the expectation for the failure.

The letter will not be addressed to the pilot by name, but ill be handed to THE PILOTS ASSOCIATION for forwarding to the pilot concerned.

5.4 Contents of record in FDA PROGRAMME DATA BASE (FDP) The following will be recorded in the FDP against the event:

-A record of any telephone debrief by THE PILOTS ASSOCIATION
-A record of any debrief by Fleet Management
-A copy of any letter sent to the pilot
-A record of any extra training given to the pilot
-Any other relevant document
-The record will not contain anything that could identify the pilot by name.

5.5 Visibility of record and pilot identity:

Flight Operations Management 's access level to FDP will reveal only that action is "open" or "closed" for each event – the actual action record is not visible. Events are not identifiable to a particular flight or pilot.

Flight Manager FDA PROGRAMME level of access to FDP will reveal the actual action taken, and can associate a pilot, by his 5 digit FDA PROGRAMME number, with that event. Actual pilot identify is not available.

THE PILOTS ASSOCIATION representative 's access to FDP is the same as the flight Manager FDA PROGRAMME, but in addition THE PILOTS ASSOCIATION representative has a decode disk to identify a pilot from his 5-digit FDA PROGRAMEM number.

5.6 It is the responsibility of the flight Manager FDA PROGRAMME to detect pilots with more than one action recorded against their 5-digitFDAPROGRAMME number within a reasonable time, and bring this to the attention of the fleet .

6. Safety DATA Request (SDR)

6.1. Flight Data for the first 15 minutes and the last15 minutes of every flight is stored in a database known as SDR. This data is available for viewing by a Flight Manager if, and only if; An SDR has been filed for that portion of that flight, or

The Captain of the flight has given his specific permission for the data to be viewed.

6.2. **I**n order to view data in SDR, the flight Manager needs to indicate, in the SDR itself, the reason for looking at the data. The reason is recorded in each case, and THE PILOTS ASSOCIATION representatives are able to view these records.

7. Retention of data

7.1 For each FDA PROGRAMME event FDP stores the raw flight data which can be viewed a s a trace or as an instrument animation. In addition, but not visible to Flight Operations management, FDP stores information which identifies the flight (by date and registration) and the pilot (by 5-digit FDA PROGRAMME number).

This data and information is required to analyze the event and to monitor, anonymously over a period of time, individual pilots' event rates.

Furthermore, SDR stores some raw flight data from each flight, as described in section 6 above.

7.2 THE AIRLLINE will not retain any longer than is necessary, and will in any case delete all flight data, and all means of identifying flights and crew, within 2 years of the flight.

7.3 For flights more than 2 years old, the FDA PROGRAMME database (FDP) will continue to contain a record of the FDA PROGRAMME events , but with all flight and crew identification removed.

8. THE PILOTS ASSOCIATION representatives' access to confidential information

8.1 In order to fulfill his/her FDA PROGRAMME obligations, THE PILOTS ASSOCIATION representative will need access to information, which is confidential to THE AIRLINE, and may be subject to the Civil Aviation Regulations. Upon appointment, a representative will be required to sign a Confidentiality Agreement, which specifies the terms under which information obtained from THE AIRLINE may be used. Breach of this agreement will lead to suspension from the FDA PROGRAMME group, and may be the subject of THE AIRLINE's disciplinary procedures.

8.2 In order to contact the crew involved in a FDA PROGRAMME event (see section 4), THE PILOTS ASSOCIATION representative will need:

- The identify of the flight (date, registration and flight number);
- The ability to identify the crew of that flight, and how to contact them; and
- An electronic copy of the flight data and means of viewing it.

8.3 THE AIRLINE will provide each PILOTS ASSOCIATION representative with a laptop computer pre-loaded with software to meet the above requirements:

- The identity of the flight will be provided by e-mail from the FDA PROGRAMME Group;
- The identity of the crew, and their contact details will be determined by remote access to the AIRLINE flight crew scheduling system; and
- The flight data will be e-mailed by the FDA PROGRAMME group, and will be viewed using the pre-loaded software.

8.4 In order to identify a pilot from his/her 5 digit FDA PROGRAMME number (see paragraph 4.2.2) THE PILOT ASSSOCIATION representative will be provided with a decode disk, for use with FDP.

8.5 Upon finishing work with the FDA PROGRAMME group, THE PILOTS ASSOCIATION representative will return the laptop and disk to THE AIRLINE. No copy of THE AIRLINE provided software may be retained.

Signed on behalf of THE AIRLINE: Singed on behalf of THE PILOTS ASSOCIATION:

Name:_____ Name:_____

Date:_____ Date:_____

Appendix C

Operators Checklist on FDA Guiding Principles

This section provides a checklist against the guiding principles that could form the basis of a FDA programme acceptable to the CAA.

Applicability:

Commercial Air Transportation under Annex 6 Part 1: an operator of an aeroplane of a certificated take-off mass in excess of 27,000 kg shall establish and maintain a flight data analysis programme as part of its accident prevention and flight safety programme. This process was recommended for all aero planes over 20,000 kg with effect from 1 January 2002, and from 1 January 2005 it was mandated for all aeroplanes in excess of 27 000 kg.

Definition:

Flight Data Analysis (FDA) is the pro-active and non-punitive use of digital flight data from routine operations to improve aviation safety.

Ref	] Objective	Process	Check
1	**Definition:** Flight Data Analysis (FDA) is the pro-active and non-punitive use of digital flight data from routine operations to improve aviation safety.	1. Statement of safety objectives. 2. Formal policy statement explicitly addressing risk management and conditions of FDA data use.	
2	**Accountability:** The manager of the accident prevention and flight safety programme, which includes the FDA programme, is accountable for the discovery of issues and the transmission of these to the relevant manager responsible for the process concerned. The latter is accountable for taking appropriate and practicable safety action within a reasonable period of time. **Note:** While an operator may contract the operation of a flight data analysis programme to another party the overall responsibility remains with the operator's accountable manager.	1. Inclusion of FDA in the AP&FSP manager's responsibilities. 2. Allocation of responsibility for discovery and transmission (normally the FDA Manager). 3. List of managers responsible for action on FDA discovered issues. 4. Agreement with third party to analyze data that details the operator's overall responsibility. (If appropriate)	
3	**Objectives** 1. To identify areas of operational risk and quantify current safety margins.	Policy Statement and Procedures on: 1. Risk identification methods as part of the operator's Safety Management System.	

Ref	Objective	Process	Check
	2. To identify and quantify changing operational risks by highlighting when nonstandard, unusual or unsafe circumstances occur. 3. To use the FDA information on the frequency of occurrence, combined with an estimation of the level of severity, to assess the safety risks and to determine which may become unacceptable if the discovered trend continues. 4. Put in place appropriate risk mitigation to provide remedial action once an unacceptable risk, either actually present or predicted by trending, has been identified. 5. Confirm the effectiveness of any remedial action by continued Analysis.	2. Process for deciding if there are changing risks 3. Defines acceptance/Action criteria including the allocation of a measure of severity. 4. Process for putting in place remedial action and ensuring it is carried out. 5. Process for deciding success/ failure criteria and follow-up	
4	**Flight Recorder Analysis Techniques** 1. Exceedance Detection: This looks for deviations from flight manual limits, standard operating procedures and good airmanship. A set of core events is used to cover the main areas of interest that are generally standard across operators. The event detection limits should be continuously reviewed to reflect the operator's current operating procedures. 2. All Flights Measurement: A system that defines what is normal practice. This may be accomplished by retaining various snapshots of information from each flight. 3. Statistics: A series of measures collected to support the analysis process. These would be expected to include the numbers of flights flown and analyzed, aircraft and sector details sufficient to generate rate and trend information.	1. Exceedance detection program tailored to operating standards. Core event set. Extended events to cover known issues. Review process in place to keep up to date. 2. Set of basic measures from every flight analyzed. 3. Support statistics compiled	

Ref	Objective	Process	Check
5	**Flight Recorder Analysis, Assessment and Process Control Tools** The effective assessment of information obtained from digital flight data is dependent on the provision of appropriate information technology tool sets. A typical program suite may be expected to include: Annotated data trace displays, engineering unit listings, visualization for the most significant incidents, access to interpretive material, links to other safety information, statistical presentations.	1. Data verification and validation process. 2. Data displays – traces and listings, other visualizations. 3. Full access to interpretive material. 4. Links with other safety systems.	
6	**Education and Publication** The operator should pass on the lessons learnt to all relevant personnel and, where appropriate, industry utilizing similar media to current air safety systems. These may include: Newsletters, flight safety magazines, highlighting examples in training and simulator exercises, periodic reports to industry and the regulatory authority.	1. Reports produced to a regular time-scale. 2. Means of distribution of safety messages. a. Newsletter or flight safety magazine. b. Simulator/training feedback. c. Other applicable departments. 3. Means of informing Industry of issues. 5. Means of informing the regulator of issues.	
7	**Accident and Incident Data Requirements** Those specified in JAR-OPS (1.160) take precedence to the requirements of a FDA system. In these cases the FDR data should be retained as part of the investigation data and may fall outside the de- identification agreements.	1. Procedures to retain and protect data where an accident or reportable incident has taken place.	
8	**Significant Risk Bearing Incidents Detected by FDA** Significant risk bearing incidents detected by FDA will normally be the subject of mandatory occurrence report by the crew. If this is not the case then they should submit a retrospective report that will be included under the normal accident prevention and flight safety process without prejudice.	1. Means of confirming if a FDA Exceedance has been the subject of a crew safety report. 2. Means of confirming the severity of each ASR and if it should be a mandatory report. 3. Means of requesting an ASR where not submitted. 4. Policy statement on non-punitive approach to retrospective reporting.	

	Objective	Process	Check
9	**Data Recovery Strategy** The data recovery strategy should ensure a sufficiently representative capture of flight information to maintain an overview of operations. Data analysis should be performed in a manner to ensure timely knowledge of immediate safety issues, the identification of operational issues and to facilitate any necessary operational investigation before crew memories of the event can fade.	1. Statement on recovery objectives and targets. 2. If not 100% analysis a method of determining a representative sample. 3. Method used to achieve timely processing and targets. 4. Analysis methods used.	
10	**Data Retention Strategy** The data retention strategy should enable the extraction of the greatest safety benefits practicable from the available data. After a period, sufficient to complete the action and review process, during which full data should be retained, a reduced data set relating to closed issues should be maintained for longer term trend analysis. Additionally a representative sample of full flight data may be retained for detailed retrospective analysis and comparison.	1. Statement on data retention policy. 2. Identification period. 3. De-identification policy and time-scales. 4. Clear policy for data retention on MORs.	
11	**Data Access and Security** Data access and security policy should restrict information access to authorized persons. Multi-level access to relevant data fields may differentiate between the various airworthiness and operational data needs, particularly in respect of flight identification.	1. Access policy statement. 2. List of persons/posts with access, data views, their use of data. 3. Procedure for secure Continued Airworthiness use of FDA data.	
	Conditions of Use and Protection of Participants nditions of use and protection given to participants should be defined in a procedure document acknowledged by all parties. The system should be non-punitive and non-attributable and hence any identification of the data must be restricted to relevant and specifically authorised persons. Secure initial identification should allow specific flight follow-up by previously agreed methods to ensure contextual information are taken into account. Where it is required that individuals receive advisory briefing or remedial training this should take place in a constructive and non-punitive manner. Included in this document will be the conditions under which the	1. Statement of policy agreed between all parties involved. 2. Clear statement of conditions of use. 3. Clear statement of Non-punitive agreement. 4. Process for withdrawal of protection. 5. Defined security procedures. 6. Process for sign up to conditions of use. 7. Method for confidential contact of crews	

Ref	Objective	Process	Check
	Confidentiality may, exceptionally, be withdrawn for reasons of negligence or significant continuing safety concern.		
13	**Airborne Systems and Equipment** Used to obtain FDA data will range from an already installed full Quick Access Recorder, in a modern aircraft with digital systems, to a basic crash protected recorder in an older or less sophisticated aircraft. The analysis potential of the reduced data set available in the latter case may reduce the safety benefits obtainable. The operator shall ensure that FDA use does not adversely affect the serviceability of equipment required for accident investigation.	1. Fully document means of data storage and recovery including installation, test and maintenance procedures. 2. Recognize and minimize the effect on the serviceability of mandatory recorders if these are used. 3. Add entry for QAR to Minimum Equipment List.	

Appendix D

FDA Programme Costs and Benefits

The following information includes a Regulatory Impact Assessment for the proposal to introduce FDA.

An FDA programme, when part of an operator's Accident Prevention and Flight Safety programme, enables an operator to identify, quantify, assess and address operational risks that are present in normal operations. As well as this being an enhancement to flight safety, current operators of FDA programmes have reported substantial cost savings being achieved. These cost saving areas include engines, fuel, maintenance, inspection and hull insurance.

Generally the costs of establishing and running and FDA programme includes:

i) Quick Access Recorder (QAR)
ii) QAR Installation costs
iii) Decoding hardware and software cost

The ongoing annual cost provided by these operators varies greatly, and appears to be inversely proportional to the fleet size. It should be noted that in spite of these costs the operator's cost benefit analysis still shows an annual saving in aircraft operations costs.

NOTE: *Where an existing FDR crash recorder is used there may be equipment cost for download devices. This would be considerably less than the cost of a QAR and its installation.*

Listed below are some of the cost and benefit aspects that should be taken into account during a cost benefit exercise:

1 Cost of an Accident

Various approaches to the cost savings through the prevention of a catastrophic accident have been attempted. The following costs could be estimated and compared with FDA system costs and benefits spread over a period of time.

- Life costs per life lost can be obtained from recent claim trends.
- Hull replacement cost.
- Third party damage costs.
- Loss of revenue due to loss of use of aircraft.
- Loss of revenue likely through lowering of public confidence.
- Reduction in company value due to stock market loss of confidence.
- Increase in insurance premium.
- Offsetting this is the insurance payment for the loss.

There would be additional industry costs that would not fall upon the individual Operator resulting from a general loss of confidence in aviation and increased overall risk levels.

Perhaps more relevant to these preventive programmes is the cost of "minor" damage accidents such as tailscrapes, heavy landings, turbulence upsets etc. The costs associated with these more common events are easier to estimate. These are often easily addressed by FDA and hence there could be a more quantifiable cost saving.

2 Non-Recurring Costs

If new equipment is to be installed on the aircraft:

- Aircraft equipment - Quick Access Recorders or other data storage devices.
- Aircraft installation hardware - cables, mountings, etc.
- Modification - design and approval of modifications.
- Installation labour costs.
- Ground replay installation - hardware and software.
- Loss of revenue due to aircraft downtime.

3 Recurring Costs

These costs may be internal or external if the processing is contracted out. Note that in this case there are still unavoidable staff costs associated with assessment and decision making.

- FDA full time staff costs.
- FDA part time staff costs.
- Continued Airworthiness and maintenance.
- Staff training.
- Media logistic costs - transporting tapes, etc.
- Consumarles - recording media, paper, etc.

4 Potential Benefits

The following examples of where FDA data has produced savings have been taken from a wide range of operators.

- Engine savings - ECM - Postponed/reduced removals, recording of use of derate.
- Fuel savings - trim analysis, airframe differences.
- Fuel tankering - more accurate burn calculations.
- Brake savings - better crew awareness and highlighting heavy use.
- Flap maintenance savings - fewer overspeeds and use as a "drag flap".
- Inspections savings - reduced number required due to availability of maximum values for heavy landings, engine over temp', flap placard, etc.
- Safety savings - improved safety estimated from probable hull loss rates.
- Insurance savings - based on experience of long term FDA operators.
- Increased aircraft availability - better/faster fault diagnosis.
- Repair savings - reduced numbers of tailstrikes, heavy landings, etc.
- Reduced ACARS costs - ECMS and other data collection from QAR.
- Increased simulator effectiveness - better targeted.
- ETOPS Analysis - automatic rather than manual.
- Warranty support - definitive usage evidence.
- Autoland support - record keeping and system health/accuracy.

Appendix E

Examples of the Aircraft Types Covered by ICAO Standards and Recommended Practices on FDA

1 Aircraft Between 20 and 27 tonnes MTOW (Recommendation)

Operators of these aircraft are recommended to have a FDA programme in place after 1st January 2002. (Refer to Chapter 8 paragraph 1.3.)

Table 1 Turbo-props

Manufacturer	Aircraft type
Antonov	An-24, 26, 30
ATR	ATR 72
BAE SYSTEMS (HS)	748, ATP
CASA	C-295
de Havilland	Dash 7
Fokker	F27, F50
General Dynamics (Convair)	580
NAMC	YS-11
Saab	2000

Table 2 Jets

Manufacturer	Aircraft type
Canadair	Challenger
Canadair	CRJ Regional Jet
Dassault Aviation	Falcon 900
Embraer	ERJ-145

2 Aircraft Above 27 tonnes MTOW (International Standard)

Operators of these aircraft are expected to have a FDA programme in place after 1st January 2005. (Refer to Chapter 8 paragraph 1.3.)

Table 3 Turbo-props

Manufacturer	Aircraft type
Antonov	An-12, 32
de Havilland	Dash 8
Ilyushin	Il-18
Lockheed	Hercules
Lockheed	L-188 Electra
Shorts	SC.5 Belfast

Table 4 Jets

Manufacturer	Aircraft type
Airbus Industrie	A300, A310, A319, A320, A321, A330, A340
Antonov	An-124, An-72, An-74
Avro	RJ, RJX
BAeS	146
Boeing	B707, B717, B727, B737, B747, B757, B767,B777, DC-8, DC-9, DC-10, MD-11, MD-80, MD-90
BAC/BAe	1-11, VC-10
Canadair	CRJ700, Global
Fokker	F27, F70, F100, F28
Gulfstream	III, IV, V
Ilyushin	Il-76
Lockheed	L-1011
Tupolev	Tu134, Tu154
Yakolev	Yak-42