Safety Regulation Group

Civil Aviation Authority

CAP 739

Flight Data Monitoring

www.caa.co.uk

Safety Regulation Group

Civil Aviation Authority

CAP 739

Flight Data Monitoring

A Guide to Good Practice

This Document outlines good practice relating to first establishing and then obtaining worthwhile safety benefits from an Operator's Flight Data Monitoring (FDM) programme. It will be regularly reviewed and revised by CAA and the Industry to reflect the wider use of FDM and developing technologies and methodologies.

---

29 August 2003

ISBN 0 86039 930 3

First Issue 29 August 2003

Enquiries regarding the content of this publication should be addressed to:
Strategic Safety & Analysis Unit, Safety Regulation Group, Civil Aviation Authority, Aviation House, Gatwick Airport South, West Sussex, RH6 0YR

The latest version of this document and all applicable amendments are available in electronic format at www.caa.co.uk/publications, where you may also register for e-mail notification of amendments.

Published by TSO (The Stationery Office) on behalf of the UK Civil Aviation Authority.

Printed copy available from:
TSO, PO Box 29, Norwich NR3 1GN
Telephone orders/General enquiries: 0870 600 5522
Fax orders: 0870 600 5533

www.tso.co.uk/bookshop
E-mail: book.orders@tso.co.uk
Textphone: 0870 240 3701

List of Effective Pages

Contents

Chapter 11 Maintaining Aircraft FDM Systems

Appendix A Terms, Definitions and Abbreviations

Appendix B Typical FDM Exceedence Detection and Routine Parameter Analysis

Appendix C Sample FDM Procedural and Confidentiality Agreement

Appendix D Operators Checklist on FDM Guiding Principles

Appendix E FDM Programme Costs and Benefits

Appendix F Examples of the Aircraft Types Covered by ICAO Standards and Recommended Practices on FDM

Appendix G Summary of United Kingdom Flight Data Recorder Requirements

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
- 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
- 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 Aeroplane Accidents Investigation. UK CAA
- UK Air Navigation Order 2000, Article 117. Mandatory Occurrence Reporting.

Amendment Record

Amendment Number	Amendment Date	Incorporated by	Incorporated on

Chapter 1 Flight Data Monitoring

The Definition of Flight Data Monitoring.

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

1 Introduction

Flight Data Monitoring (FDM) programmes assist an operator to identify, quantify, assess and address operational risks. Since the 1970's the CAA's Safety Regulation Group (SRG) has helped develop and support such systems and used FDM information 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 FDM such that the International Civil Aviation Organization (ICAO) have recommended their use for all Air Transport operations in aircraft of over 20 tonnes maximum weight. Further, they are making FDM a standard for all such operations of aircraft over 27 tonnes with effect 1st January 2005. The UK, in continuing its policy of applying ICAO standards, will make this a requirement under UK law and other European regulators are also expected to comply.

The UK Air Navigation Order 2000 (ANO 2000) Article 34A will require the establishment and maintenance of an Accident Prevention and Flight Safety Programme (AP&FSP) and includes the requirement for FDM. The content of safety programmes, including FDM, will need to be confirmed as acceptable by the CAA's Flight Operations Inspectors.

It is recognised 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 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.

In a similar manner to the ICAO Accident Prevention Manual (Doc 9422), this document outlines good practice and indicates what may constitute an operator's FDM programme system that is acceptable to the CAA. It is intended to be regularly reviewed and revised by CAA in consultation with Industry as widespread FDM experience develops.

1.1 Document Structure

This document includes the following elements:

Chapter 2:	Objectives of an operator's FDM System.
Chapter 3:	Description of a Typical FDM System.
Chapter 4:	FDM within a Safety Management System.
Chapter 5:	Planning the Introduction of FDM.

Chapter 6: Organisation and Control of FDM Information.

Chapter 7: Interpretation and Use of FDM Information.

Chapter 8: Legislation and Requirements related to FDM.

Chapter 9: Legislation Related to FDM Information.

Chapter 10: Mandatory Occurrence Reporting and FDM.

Chapter 11: Maintaining Aircraft FDM systems

1.2 **Purpose of this Document**

This document is designed to meet the following objectives:

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

1.3 **Useful Terms, Definitions and Abbreviations**

A list of useful terms, definitions and abbreviations associated with FDM is given in **Appendix A** to this document.

1.4 **Comments on this Document**

This document has been developed by the Strategic Safety & Analysis Unit of the Design & Production Standards Division in consultation with other SRG specialists. **It is intended that this should be a living document so SRG welcome change proposals, comments and additions from Industry.** Please write to:

Strategic Safety & Analysis Unit
Safety Regulation Group
Civil Aviation Authority
Aviation House
Gatwick Airport South
RH6 0YR
Or e-mail: david.wright@srg.caa.co.uk

Chapter 2 Objectives of an Operator's FDM System

A FDM system 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 FDM system should be constructed so as to:

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

Initially a FDM 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 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.

3 To use the FDM 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.

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.

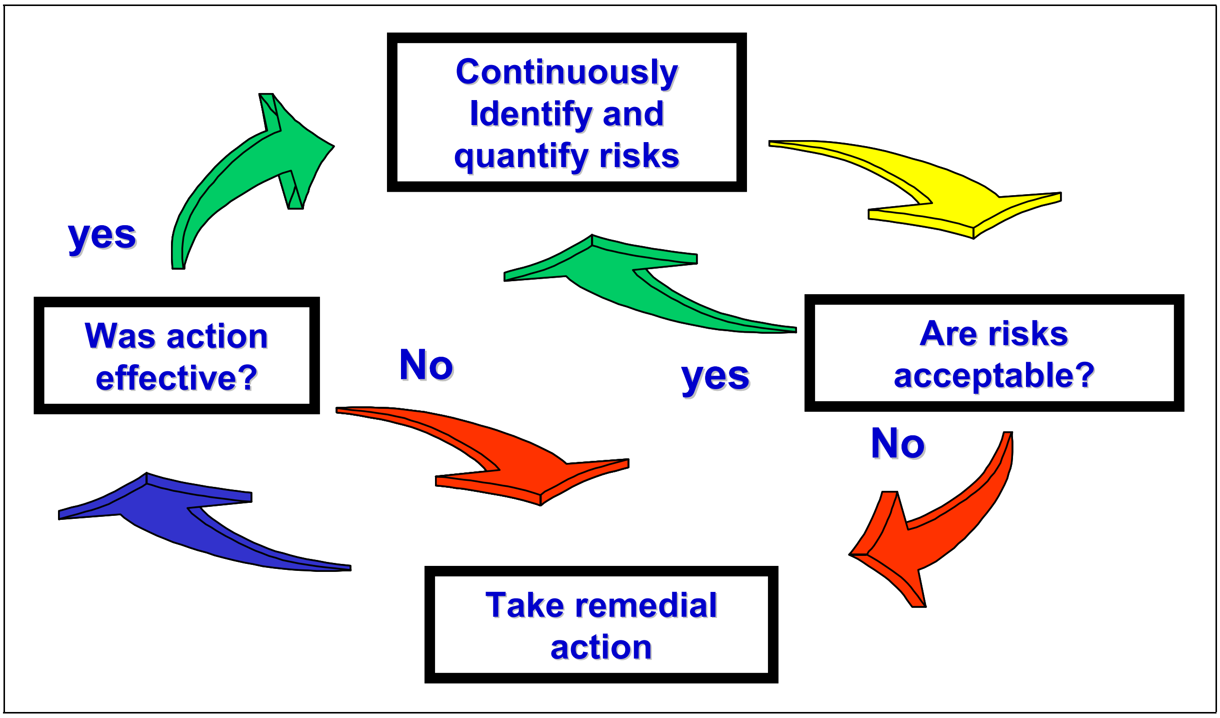
Once an unacceptable risk, either actually present or predicted by trending, has been identified, then appropriate risk mitigation techniques must be used to put in place remedial actions. This should be accomplished while bearing in mind that the risk must not simply be transferred elsewhere in the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

5 Confirm the effectiveness of any remedial action by continued monitoring.

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.

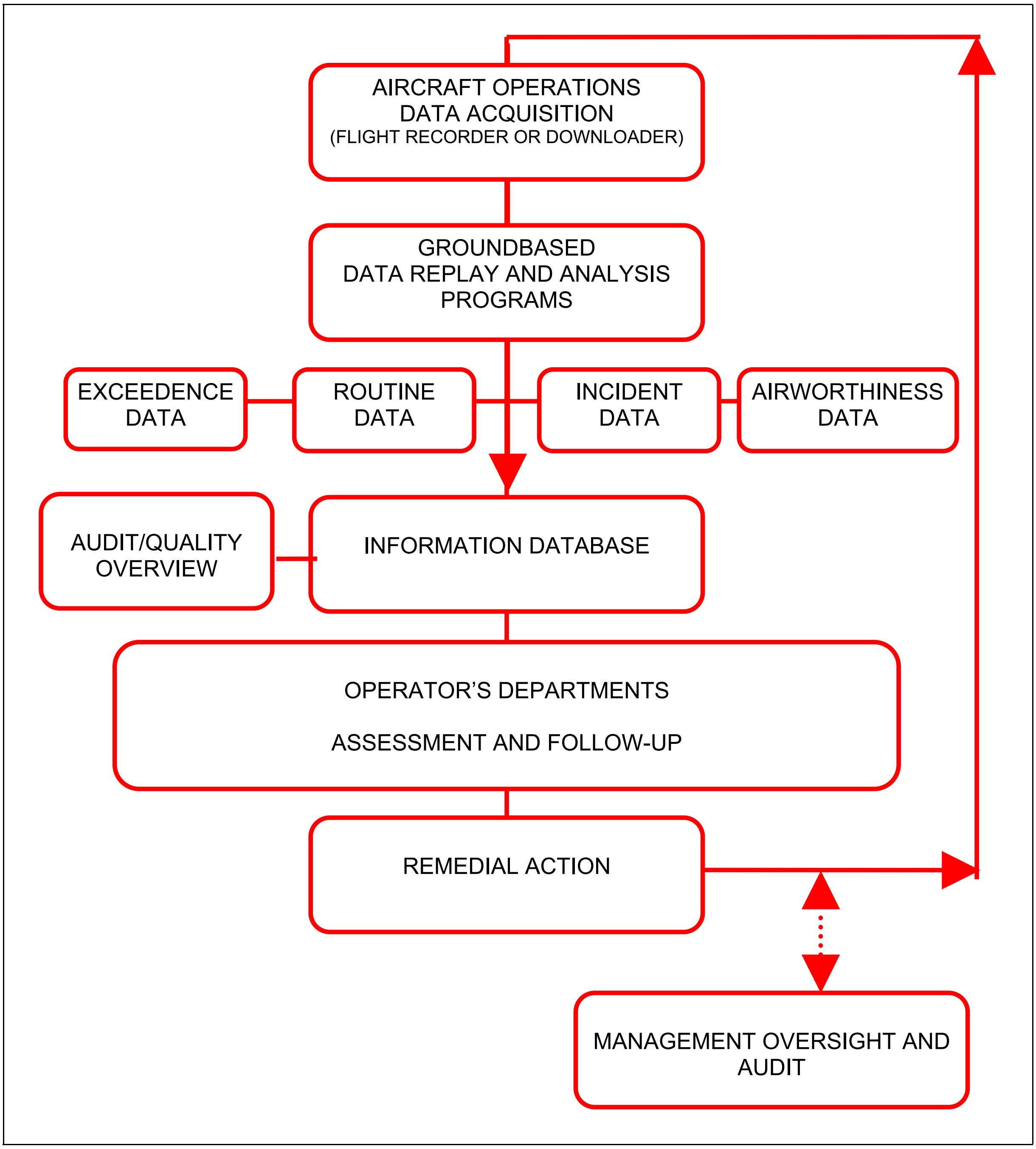
Example: Confirm that the other measures at the airfield with high rates of descent do not change for the worse after changes in approach procedures**.**



Chapter 3 Description of a Typical FDM System

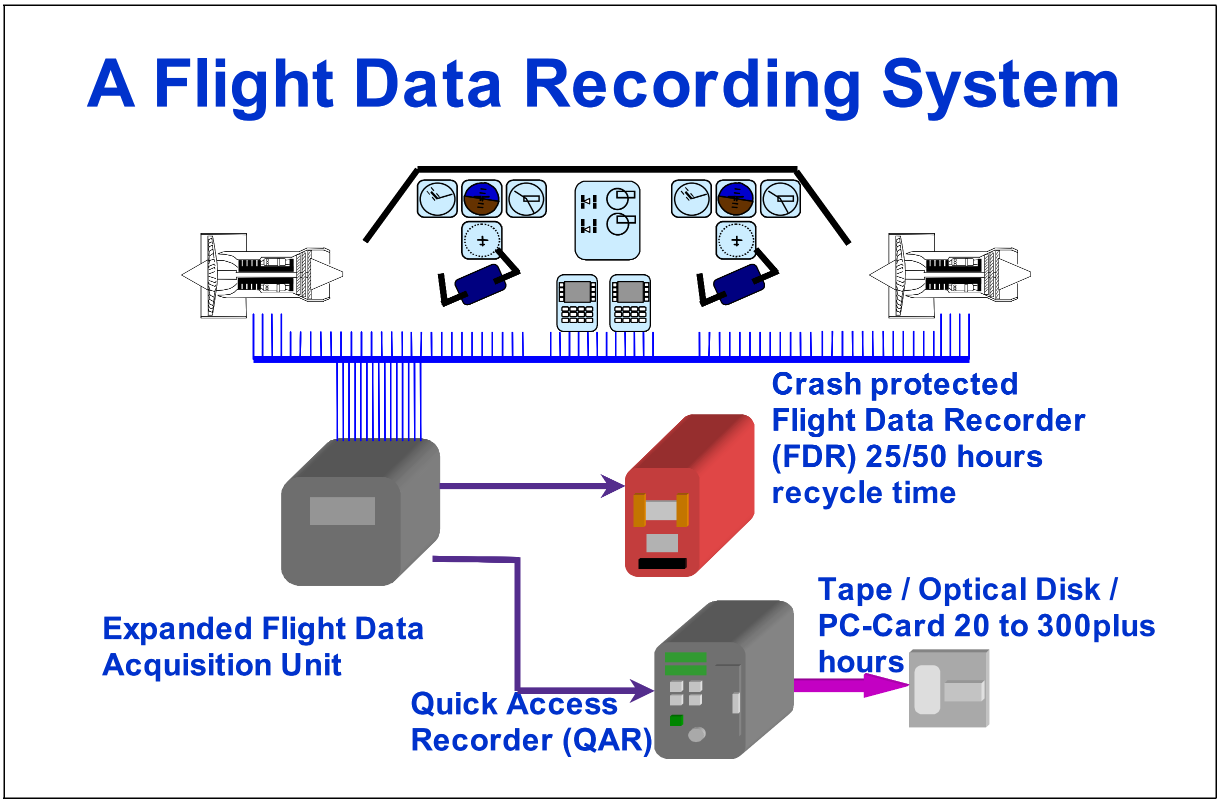
This chapter describes the principal components of a typical FDM system. This is not necessarily an optimum system but one that reflects current practice. Details of other options are shown in subsequent chapters.

1 System Outline - Information Flow



2 Aircraft Operations - Data Acquisition

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.

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.

The technology also exists to download straight from an onboard storage device to an operator's file server via wireless links. This reduces the logistical problems associated with the movement of media or physical downloading tasks.

Chapter 5 paragraph 6 technical specification gives an outline of some of the current technologies applicable to FDM.

3 Ground-Based Data Replay and Analysis Programs

The tapes/disks are logged in and replayed through a suite of computer programs starting with one that converts the raw binary data into engineering units. Aircraft, recorder and tape/disk data quality and other checks are made and recorded for trending purposes. 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.

4 The Information

4.1 Exceedence Detection

Exceedence or event detection is the traditional approach to FDM 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 glideslope, heavy landing.

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 characterise each flight and allow comparative analysis of a wide range of aspects of operational variability.

Examples of parameters: 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.

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 JAR-OPS and hence de-identification of the data, required to maintain FDM 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.

Examples of Incidents where FDR data could be useful: vortex wake encounters; all flight control problems; system failures that affect operations; emergencies such as high speed abandoned take-offs; TCAS or GPWS triggered manoeuvres.

4.4 Continued Airworthiness Investigation Data

Both routine and event data can be utilised to assist the continued airworthiness function. Engine monitoring 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.

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

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.

6 Operator's Departments - Assessment and Follow-up

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 realised. 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.

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 non-handling pilot. It stressed the importance of a team effort during go-arounds.

8 Continued Monitoring

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 FDM within a Safety Management System

The principles behind successful Safety Management Systems (SMS) are the same as those for FDM 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 FDM programme functions within it.

1 Safety Management Systems (SMS)

1.1 What is a Safety Management System?

Based on the ICAO Annex 6 Pt 1 recommended practice, JAR–OPS 1.037 states that "an operator shall establish an accident prevention and flight safety programme, which may be integrated with the Quality System, including programmes to achieve and maintain risk awareness by all persons involved in operations". 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 CAA publication, CAP 712 – "Safety Management Systems for Commercial Air Transport Operations", was developed as guidance material for commercial air transport operators and maintenance organisations to assist them in developing effective and comprehensive systems for managing safety. It defines safety management as:

> '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.

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

- A comprehensive corporate approach to safety,
- An effective organisation 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 Monitoring by Line Managers.

2 The Safety Culture

2.1 Safety Management Policy

The operator should have a top-level commitment to a business objective that minimises 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 individual involved are aware of and are held accountable for.

2.2 Open Safety Conscience

The FDM 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.

2.3 Involvement at all Levels

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

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 FDM system. Methods used in successful Air Safety Reporting systems should be employed here.

2.5 FDM Integrated within the Safety Management System

An FDM 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 monitoring 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 monitoring, ATC and scheduling are just a few of the areas that could benefit.

2.6 The Safety Culture Covers all Safety Monitoring Systems

The culture must cover, bring together and integrate information from the many diverse sources of data within the operator. FDM, 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.

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 FDM process would be expected to be continuously audited for fulfilment of this aspect by a high level safety board or similar group.

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.

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

3 Risk Identification

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 are detailed in the Joint Aviation Requirements (JAR 23 and 27 and 25:1309) and explained in CAP 712 Appendix B. 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 procedures

The probability of occurrence, or likelihood, as defined in both qualitative terms and in quantitative terms in CAP 712 Appendix C, 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 several times when considering several systems of the same type.

	Probability of Occurrence	Quantitative definition	Qualitative definition
4	**Probable**	• between 1 and 10^{-5} per flight hour	• 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^{0}	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}	10^{-9}
JAR 25 Qualitative Proby. of Occurrence	FREQUENT			REASONABLY PROBABLE		REMOTE		EXTREMELY REMOTE		EXTREMELY IMPROBABLE
Category of Effect	MINOR					MAJOR		HAZARDOUS		CATASTROPHIC

3.2 Determining what is Acceptable

In practical terms, experience can be displayed as a risk tolerability matrix as shown below in the table taken from CAP 712. 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. Present and potential risk is discussed further in this chapter.

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 Glideslope warning was not a problem as the aircraft was on the centreline and not on a terrain critical approach**.**

Severity and Likelihood

SEVERITY

Catastrophic	4	4 Review	8 Unacceptable	12 Unacceptable	16 Unacceptable
Hazardous	3	3 Acceptable	6 Review	9 Unacceptable	12 Unacceptable
Major	2	2 Acceptable	4 Review	6 Review	8 Unacceptable
Minor	1	1 Acceptable	2 Acceptable	3 Acceptable	4 Review
		Extremely Improbable *1*	*Extremely Remote* *2*	*Remote* *3*	*Probable* *4*

LIKELIHOOD OF OCCURRENCE

NOTE: The numbers used in the table are the product of the severity/likelihood assessments. The matrix is used to prioritise actions to mitigate risk.

THIS TABLE ILLUSTRATES ONE POSSIBLE CLASSIFICATION SCHEME.
THE ACTUAL SCHEME USED MUST BE STATED IN THE DOCUMENTATION.

Figure 1 Example of a Risk Tolerability Matrix (Source: Cap 712 Appendix D)

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 FDM programme that will provide identification and measures to support expert opinion and experience. All available sources of safety data should be utilised 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, FDM exceedence data, FDM routine measurements, airport assessments etc.

3.2.2 Giving a Baseline against which to Measure Change

The results of the FDM 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….

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 realised risk is useful, it only serves to identify mitigation targets - that is the traditional approach to accident investigation and follow-up. FDM, and indeed all other risk defining data needs to be rather more subtly analysed 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; glideslope/localiser tracking vs GPWS or CFIT.

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 monitoring system. The aim of this would be to flag up the trend of a much lower level measure towards the exceedence 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.

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 defence 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.

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.

3.2.7 Highlighting Risk Areas not Identified by SMS

The SMS process depends on a combination of recognised sources of risk combined with a safety net that will catch unpredicted risks before they are realised. The generalised FDM 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.

3.3 How a SMS can Benefit from FDM

3.3.1 FDM 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 monitoring all flights, FDM 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.

3.3.2 A Summary of SMS Benefits from the Implementation of FDM

1. Gives a knowledge of actual operations rather than assumed.
2. Gives a depth of knowledge beyond accidents and incidents.
3. Setting up a FDM 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-modelling 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.

3.4 How FDM can Benefit from Incorporation within a SMS

3.4.1 SMS Provides a Structured Environment for a FDM Implementation

The implementation of FDM 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.

3.4.2 A Summary of FDM Benefits from the Incorporation within a SMS

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

Chapter 5 Planning and Introduction of FDM

This chapter describes the development and implementation of FDM within an operator. It is recognised that there are a wide range of operators covered by the FDM 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.

1 FDM 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. These are expected to be reflected in JAR-OPS 1.037 Advisory Circular Joint (ACJ) that will be associated with proposed requirements.

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 FDM
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

2 FDM Programme Costs and Benefits

Much has been said about the safety benefits of FDM 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 to the CAA so **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.

3 The Implementation Plan

This is a broad guide to the major steps involved in putting an FDM 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 FDM 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 organisational 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.

4 Aims and Objectives

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 monitoring etc. added in the second phase. Ensure compatibility with other systems.

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 (S1) Establish data download procedure, test replay software, identify aircraft defects. **(S2)** Validate and investigate exceedence data. **(S3)** Establish a User acceptable routine report format to highlight individual exceedences and also statistics.

Medium term (M1) Produce annual report - include key performance indicators. **(M2)** Add other modules to analysis (e.g. Continued Airworthiness). **(M3)** Plan for next fleet to be added to programme.

Long Term (L1) Network information across company information systems. **(L2)** Ensure FDM provision for any proposed "Advanced Qualification Program" style training. **(L3)** Use utilisation and condition monitoring to reduce spares holdings.

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 monitoring methods for all locations.

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.

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 The FDM Team

UK experience has shown that the "team" required to run an FDM programme can vary in size from one person with say a five aircraft fleet, to a small department looking after scores of aircraft. The description below describes the various roles within a larger system in some detail. 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 FDM 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.

5.1 Team Leader

This person will be trusted by and given the full support of both management and crews. They may have direct crew contact in situations that require diplomatic skills. They will be able to 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.

5.2 Flight Operations Interpreter

This person will normally be a practising or very recent pilot, possibly a senior Captain or trainer, who knows the company's route network and aircraft. Their in depth knowledge of SOPs, aircraft handling characteristics, airfields and routes will be used to place the FDM data in context.

5.3 Airworthiness Interpreter

This person will interpret FDM data on technical aspects of the aircraft operation. They will be familiar with the powerplant, structures and systems departments requirements for information and also any existing monitoring techniques employed by the operator.

5.4 Crew Liaison Officer

This person will be the link between the fleet or training managers and aircrew involved in circumstances highlighted by FDM. This person is often a British Airline Pilot's Association (BALPA) or other staff representative with good people skills and a positive attitude towards safety education. It is essential that the post holder has the trust of both crew and managers for their integrity and good judgement.

5.5 Engineering Technical Support

This will be an individual who is knowledgeable about the FDM and associated systems needed to run the programme. An avionics specialist, normally is also involved in the supervision of mandatory FDR system serviceability.

5.6 Air Safety Co-ordinator

This person will be involved with the follow-up of Air Safety Reports and will be able to put the FDR data into the context of ASRs and vice versa. This function ensures read-across between the two systems and should reduce duplication of investigations.

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.

6 Technical Specification

6.1 Data Recording Technology

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

Mandatory Crash Recorders

JAR–OPS 1.715-1.727 Flight data recorders – describes the carriage requirements for aircraft first issued with an individual Certificate of Airworthiness on various dates with the latest standards applying to those issued on or after 1 April 1998. The parameters needed to meet the JAR-OPS 1.715 are defined in appendices to each of the specified paragraphs. Further information can be found in EUROCAE Minimum Operational Performance Specification for Flight Data Recorder Systems, Document ED 55 and ED 112.

In the UK some Air Operator Certificate holders still work to the ANO 2000 Schedule 4, Scales P and S and hence to the earlier CAA Airworthiness Specifications 10 and 10A.

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 unauthorised staff as these records are protected by law in the UK.

Quick Access Recorders (QARs)

Quick Access Recorders are normally fitted on a "no hazard-no credit" basis. They should satisfy the environmental test requirements for equipment specified in the latest versions of ED 14 or DO160. General standards, naming conventions etc. specified in ED 55 should be applied where appropriate to enable common software and interpretation with the DFDR system.

- **Tape** (QAR) - traditional medium for FDM 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+ capacity 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.

6.2 **DFDR Downloads - SSDFDR and Tape DFDR**

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 than 10 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 a 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 B 1.160 requirements are given in Chapter 8). Subject to CAA 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.

6.3 **Maintenance Recorder Downloads**

Standard PC floppy disks are the normal medium used to download system 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.

6.4 **Onboard Analysis**

A few operators have implemented on-board monitoring programmes that perform analysis almost in real time. This has the advantage that only small amounts of data, surrounding the interesting event, need to be transferred. The disadvantage is that if this snapshot is the only data available, then information on the pre and post incident context is lost. Alternatively, 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.

6.5 **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 on-board system transmits the flight data as the aircraft taxis in to the terminal and it is then transferred using the operator's information network. This 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 CAA.

7 Analysis Program Specification

An analysis program specification document has to be constructed to fulfil 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.

7.1 Process Definition from Aircraft to Archive

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

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.

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 discretes that are never seen during normal operations. Guidance in this area can be obtained from the processes involved in the verification of the mandatory recorder details of which may be found in CAP 731 - "The Approval, Operational Serviceability and Readout of Flight Data Recorder Systems"
- **Testing exceedence 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.

7.4 **Exceedence Detection**

This is the traditional approach to FDM 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 lift-off rotation rate, stall warning, GPWS warning, flap limit speed exceedence, fast approach, high/low on glideslope, 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 take-offs, go-arounds, 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.

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.

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 B paragraph 2**.

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

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 FDM data has proven very useful in determining what is normal as opposed to the event method that gives what is abnormal. See **Appendix B 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.

7.8 **Onboard Eventing and Measurement**

Some operators have used in-flight exceedence 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 autoland reporting.

Chapter 6 Organisation and Control of FDM 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 authorised to view it.

This section deals primarily with enabling the efficient handling of exceedences (or events) produced by an FDM programme. These exceptions to normal operating practice, good airmanship and flight manual limitations will be highlighted ready for evaluation and action.

1 Rationalised Data Stream

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.

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 FDM software should automate as much of this process as practical.

1.3 **Identification of Urgent Actions**

There are a number of circumstances where FDM 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.

1.4 **Allocation of Follow-up Co-ordinator**

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 organisations and in this case the follow-up co-ordinator will act as a focal point for the investigation.

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.

1.6 Record all Actions Taken

An important part of the assessment of a new FDM 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.

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.

2 Data Flow

The data flow should be optimised to minimise 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.

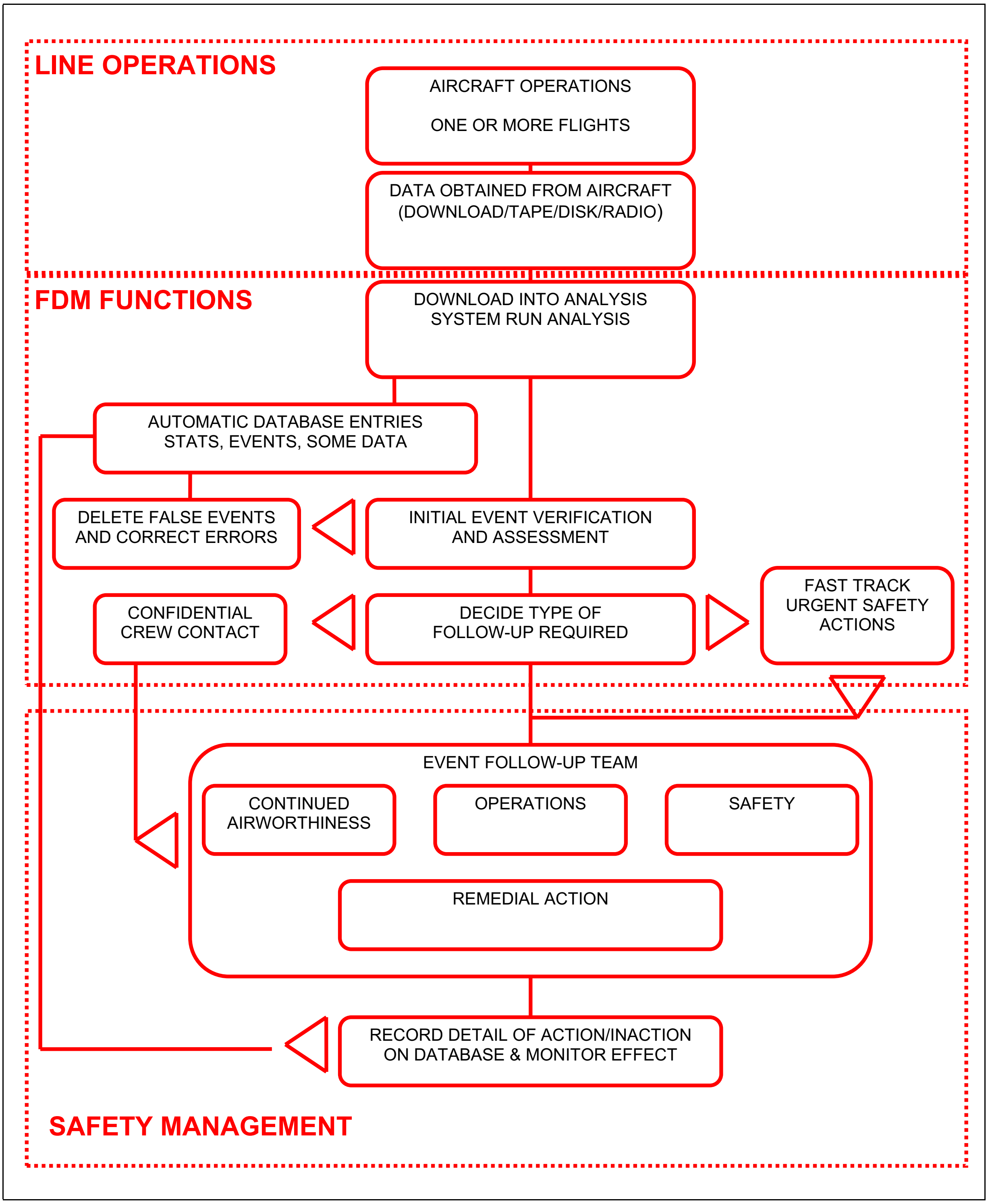


Figure 2 FDM Data Flow

3 Data Security and Control

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.

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 FDM 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 FDM programme. The crew should be encouraged to submit an ASR without prejudice via a confidential contact method.

3.3 Engineering use of FDM Data

It must be recognised that the use of FDM and associated data sources for Continued Airworthiness purposes is 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 FDM data should not be permitted through this path.

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 non-disclosure 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 UK 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.

3.5 Crew Identification in Mandatory Occurrences

An exception to the de-identification of FDM 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. CAA CAP 382 (The Mandatory Occurrence Reporting Scheme) stresses that a safety rather than disciplinary approach should to be taken in these cases.

3.6 Set Authorised Access Levels

The FDM 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.

4 Crew Participation

4.1 Agree Joint Aim - to Improve Safety and Non-punitive

It is fundamental that all involved in FDM 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.

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.

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 publicised 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 visualisations/ animations would, in some cases, be useful during this process.

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.

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 used by the CAA's Chairman in respect of the UK Mandatory Occurrence Reporting Scheme 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 authorises disclosure." (CAP 382)

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 behaviour, where the crew have "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.

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.

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 analysing 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 FDM Information

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.

1.1 Validation Checking Strategy

Most parameters required for the FDM 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 re-certification 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 overspeed.

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 g peaks!

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.

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 Positon	Yaw Control Position	Pitch control surface position	Lateral control surface position	Yaw control surface position	Lateral acceleration	Pitch trim surface position	Trailing edge Flaps	Leading edge Flaps Slats	Trust Reverse position	air ground sensing	Angle 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 tranceiver		✓						■															
(9) Thrust of each engine		✓							■												✓	✓	
(11) Longitudinal Acceleration					✓					■							✓	✓	✓	✓	✓	✓	
(18) Pitch Control Position					✓	✓					■			✓				✓					✓
(19) Roll Control Position				✓			✓					■			✓								
(20) Yaw Control 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 or 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)

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 Exceedence 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.

1.6 **Keep Examples for Future Training**

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

2 Interpretation of Results - The Operational Assessment

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

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.

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.

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.

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…

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.

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.

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.

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.

2.9 Continuous Monitoring 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 FDM

This chapter summarises some of the legislation and requirements that surround the area of FDM 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.

1 Accident Prevention and Flight Safety Programmes

ICAO Annex 6, Part 1, International Commercial Air Transport – Aeroplanes 3.6.1 requires that "an operator shall establish and maintain an accident prevention and flight safety programme." Guidance is contained in the Accident Prevention Manual (Doc 9422) and in the Preparation of an Operations Manual (Doc 9376). This is then picked up in the JAA's Interpretive and Explanatory Material (IEM) to JAR OPS 1.037 – shown below.

The UK Air Navigation Order 2000 (ANO 2000) Article 34A will require the establishment and maintenance of an accident prevention and flight safety programme (AP&FSP) and includes the requirement for FDM. The content of safety programme's, including FDM, will need to be confirmed as acceptable by the CAA's Flight Operations Inspectors.

Finally, the ICAO Amendments to Annex 6 that specify new provisions pertaining to flight data analysis programmes are detailed. These are again likely to be required under JAR OPS 1.037 and specified in IEM guidance material that is yet to be approved. It is anticipated that the FDM Guiding Principles shown in **Appendix D** will form the basis of this material.

1.1 JAR-OPS 1.037 Accident Prevention and Flight Safety Programmes

(a) An operator shall establish an accident prevention and flight safety programme, which may be integrated with the Quality System, including:

(1) Programmes to achieve and maintain risk awareness by all persons involved in operations; and

(2) An occurrence reporting scheme to enable the collation and assessment of relevant incident and accident reports in order to identify adverse trends or to address deficiencies in the interests of flight safety. The scheme shall protect the identity of the reporter and include the possibility that reports may be submitted anonymously.

(3) Evaluation of relevant information relating to accidents and incidents and the promulgation of related information.

(4) The appointment of a person accountable for managing the programme.

(b) Proposals for corrective action resulting from the accident prevention and flight safety programme shall be the responsibility of the person accountable for managing the programme.

(c) The effectivenss of changes resulting from proposals for corrective action identified by the accident and flight safety programme shall be monitored by the Quality Manager.

1.2 JAR-OPS IEM OPS 1.037 (Interpretive and Explanatory Material)

1. Guidance material for the establishment of a safety programme can be found in:
   a. ICAO Doc 9422 (Accident Prevention Manual); and
   b. ICAO Doc 9376 (Preparation of an Operational Manual).
2. Where available, use may be made of analysis of flight data recorder information (See also JAR-OPS 1.160(c).)

1.3 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 F**.

ICAO Annex 6 Part 1 - CHAPTER 3. GENERAL

3.6 Accident prevention and safety programme

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

3.6.2 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.

3.6.3 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.

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

2 Requirements - JAR-OPS Rules for Retention of Data for Accidents and Reported Occurrences

This section describes the requirement to retain flight recorder data following an accident, or more commonly, an incident that is subject to mandatory reporting. Considerable planning has to go into workable procedures to ensure the retention of such data. Prompt action is required to prevent overwriting of the crash recorder data (normally a 25 hour overwrite cycle) and possibly to quarantine the QAR data if this has been deemed an acceptable substitute/backup.

JAR–OPS 1.160 Preservation, production and use of flight recorder recordings

(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.

Paragraph (c) then describes the limitations placed on the use of such data:

(c) Use of recordings

(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.

3 Requirements – Mandatory Occurrence Reporting Scheme

In the United Kingdom Article 117 of the ANO 2000 imposes a duty on a number of specified persons, including the operator and commander of a public transport aircraft and maintenance organisations, to report to CAA:

ANO 2000 Article 117 (2)

(a) ….'reportable occurrence' means:

(i) any incident relating to such an aircraft or any defect in or malfunctioning of such an aircraft, or any part or equipment of such an aircraft, being an incident, malfunctioning or defect endangering, or which if not corrected would endanger, the aircraft, its occupants or any other person ; and

(ii) any defect in or malfunctioning of any facility on the ground ……… endangering, or which if not corrected would endanger, such an aircraft or its occupants.

> ANO 2000 Article 117 (5)
>
> (a) ……. The operator of an aircraft shall, if he has reason to believe that a report has been made or will be made in pursuance of this article, preserve any data from a flight data recorder or a combined cockpit voice recorder/flight data recorder relevant to the reportable occurrence for 14 days from the date on which the report of that occurrence is made to the CAA.…
>
> (b) The record …..may be erased if the aircraft is outside the United Kingdom and it is not reasonably practicable to preserve the record until the aircraft reaches the United Kingdom.

This means that information obtained by an operator when analysing 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 Recurrence Reporting Scheme. The implications are discussed in Chapter 10.

4 Requirements - DFDR Carriage Requirements

JAR–OPS 1.715, 1.720, 1.725 Flight data recorders – describes the accident investigation recorder carriage requirements for aircraft first issued with an individual Certificate of Airworthiness (C of A) on various dates and the latest standards applying to those with C of A's issued on or after 1 April 1998. Because of the numerous requirements dependent upon the certification date and aircraft weight, a summary of United Kingdom Flight Data Recorder Requirements is given in **Appendix G**. The reader should note that this table is not definitive and the appropriate official documents should be consulted for a definitive view.

The parameters to meet JAR-OPS 1.715 are defined in EUROCAE Minimum Operational Performance Specification for Flight Data Recorder Systems, Document ED 55.

The operational performance requirements for Flight Data Recorders are laid down in ICAO Annex 6 (Operation of Aircraft) fifth edition of Part I dated July 1990.

5 Requirements - DFDR Engineering Data Decoding Specification

The need for retaining information for the decoding of the mandatory recorder data is outlined in ED 55's general standards, naming conventions etc. but not directly specified in a requirement. International efforts are being made to ensure that the information required for reliable decoding for accident investigation is properly retained by all operators.

The Canadian Transportation Development Centre has developed a useful tool to assist in this task. The Flight Recorder Configuration Standard (FRCS) and FRCS Editor are designed to solve the difficulties by providing a standardised format for maintaining FDR information. Both the standard and editor can be downloaded free of charge from the Canadian company, xwave's Web site at (**http://frcs.cbu.xwave.com**) or from the Transportation Development Centre Web site (**http://www.tc.gc.ca/tdc/projects/air/8637.htm**). For further information contact the Transportation Development Centre, 800 René Lévesque Blvd. West, Suite 600, Montreal, Quebec, Canada H3B 1X9.

6 Requirements - QAR Installation

Quick Access Recorders are normally fitted on a "no hazard-no credit" basis. They should satisfy the environmental test requirements for equipment specified in EUROCAE ED-14 or RTCA DO160.

7 Requirements - QAR Serviceability and MELs

While there are no specific requirements for these non-mandatory recorders, if, after CAA approval, the data is to be used to replace DFDR downloads for incidents then a similar standard would be expected. However, in the event of a QAR being unserviceable then the DFDR would of course be available provided a timely data download is made. The confirmation of acceptable data on the QAR must always take place within the DFDR overwriting time-scale.

The UK CAA have issued a Master Minimum Equipment List Temporary Revision (MMEL TR-G5) to Update MMELs to include current CAA MMEL Policy on Quick Access Recorders.

ATA 31 – INDICATING/RECORDING

Insert this page facing page 31-1 of the MMEL

1. Quick Access Recorders (QAR)	A	-	-	May be inoperative subject to arrangements approved by the CAA. Note: Any alleviation and corresponding rectification interval will be dependent on the usage requirements of the QAR for individual operators, and will be subject to approval by the CAA.

Essentially this means that the status of the QAR or equivalent data system is dependant on the criticality of the uses to which the data is put.

See also Chapter 11 – Maintaining Aircraft FDM Systems.

Chapter 9 Legislation Related to FDM Information

This chapter explores the interaction of the FDM process, actions taken by the operator and the information that FDM produces with underlying UK law. Much of this area has yet to be tested in the UK courts 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 FDM exceedence 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 FDM 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.

1 Legal Responsibility for Conduct

It is important to recognise the limitations placed on the conduct of aviation professionals by the law, in particular, the criminal offence of endangering due to **reckless** or **negligent** behaviour. These need to be understood when constructing the protective agreements in FDM programmes – referred to in Chapter 10 and **Appendix C**. 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.

1.1 Legal Terms - Endangering

In addition to the specific offences contained in The Air Navigation Order 2000 and its 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, under Article 63 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, under Article 64 “a person shall not recklessly or negligently cause or permit an aircraft to endanger any person or property.”

1.2 Legal Terms - Recklessness

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

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. Lord Denning stated in one case that "it is so easy to be wise after the event and to condemn as negligence that which was only misadventure. We ought always to be on our guard against it". In another case he stated that "a mere error of judgement is not negligence."

2 Data Protection Act, Human Rights Acts and Legal Discovery

The aviation professional may be concerned that FDM data is being collected and analysed 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 FDM. In practice, with well-devised organisation and control of the FDM process, the aviation professional should be reassured. This section examines some of the legal issues surrounding the retention of FDM data that helps minimise the potential for unwarranted intrusion on the individual.

2.1 Data Protection Act (DPA)

This applies to personal data held on computer or stored on paper. Data held by an operator, which is de-identified, is not subject to the Data Protection Act per se. However, if FDM data **can be** (not necessarily **is**) linked to personal data files also held by the operator (or on its behalf) it becomes personal data. I.e. if a crew roster database can be linked with the FDM database to identify individuals then the DPA will apply. Under the DPA the person to whom that data relates can demand access to that data.

The Acts impose an obligation on the retainer of the information to process it fairly, retain it for lawful purposes only, retain only relevant and not excessive data and to keep it accurate and up to date. This should not present any problems if the FDM process has been constructed so as to ensure valid and secure data is used following good working practices and for carefully defined purposes.

2.2 Human Rights Act 1998

This Act gives people various rights that must be respected by everyone but can be infringed in the public interest. For example, recording cockpit conversations is arguably a breach of the flight crewmembers right to a private life. However it is also arguably permissible to infringe this right in the interests of public safety. But it may not be permissible to infringe this right in the interests of securing a criminal conviction. The operator must consider the implications of this Act and be able to justify denying the flight crewmember the right to unrecorded private conversations with other flight crewmembers. (Please note: FDM does not include any cockpit voice recording data.)

2.3 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.

Considering the Statute of Limitations – Breach of Contract claims must generally be brought within 6 years. Personal injury claims must be brought within 3 years of either the incident which caused the injury or when the claimant became aware of his injury. (Asbestos claims were brought years afterwards, once asbestos damage was scientifically recognised.) Some criminal charges must be brought within 6 months, whilst the more serious have no time limit.

2.4 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 FDM 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 - 3 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 de needed for evidence.

In criminal proceedings there is no disclosure by the Defendant as set out in relation to civil proceedings above. However, the Police have certain powers to seize documentation/records when investigating an offence. 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.

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 FDM

This chapter deals with the practical issues arising when FDM information is used in the follow-up process. The regulations for Mandatory Occurrence Reporting in the UK are given in Chapter 8 paragraph 3.

Once it has been ascertained that there is significant actual or potential risk associated with an issue raised by **any** safety monitoring 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 FDM into this existing and trusted system.

1 Air Safety Reports and Mandatory Occurrence Reporting

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.

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 publicised to increase awareness.

1.3 Retention of FDR data for MORs

CAP 382, Mandatory Occurrence Reporting Scheme, gives the following advice:

> 11.1 The CAA expects to use flight recorder data only when this is necessary for the proper investigation of the more significant occurrences. It is not intended to use such data to check on information contained in a written report, but to supplement and extend the written information. Examples of the types of occurrence for which flight data records would be most useful are: significant excursion from the intended flight parameters; significant loss of control or control difficulties; unexpected loss of performance; a genuine GPWS warning. However the more comprehensive recorders fitted to some aircraft are capable of providing valuable data on a wider range of occurrences and the CAA would expect to make judicious use of such information in relation to appropriate occurrences.

11.2	For this purpose, the ANO requires that operators retain the date from the FDR which is relevant to a reportable occurrence for a period of 14 days from the date of the occurrence being reported to the CAA, or a larger period if the CAA so directs.
11.3	The CAA depends upon the judgement of those responsible for submitting reports to establish which occurrences require the retention of FDR data. It is equally incumbent upon the CAA to advise the reporting organisation as quickly as possible when it requires such data.
	CAP 382 March 2003

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 DFDRs makes it critical that a decision to quarantine the data is taken very rapidly. Experience shows that this is a very difficult requirement to fulfil. 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 DFDR.

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. This is highlighted in the MOR guidance material (CAP 382).

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 FDM 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 FDM events can be used to add to the understanding of the circumstances of the incident. It is important to emphasise that it is not the purpose of the process to check out the reporter’s recollection and accuracy.

1.5 **Withdrawal of Protection of Identity**

UK experience has shown that very rarely there will be cases where an important issue has been raised by FDM 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 emphasised 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 FDM information is concerned with lower levels of hazard where no identification is needed.

1.6 Confidentiality and Mandatory Occurrence Reports

It should be noted that while MORs are not subject to FDM 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. CAP 382 instructs:

> 6.1.8 If any reporter considers that it is essential that his/her identity not be revealed, the report itself should be clearly annotated 'CONFIDENTIAL' and submitted direct to SIDD Gatwick, addressed to 'Head of SIDD' and the envelope should be marked 'Personal'. The request will be respected and the reporter will be contacted personally, either by the Head of SIDD or his deputy. CAA cannot, of course, guarantee confidentiality when an occurrence is reported separately by another party or where the caveat on prosecution in the Chairman's statement in this CAP applies, i.e. 'dereliction of duty amounting to gross negligence'. Reporters submitting a Confidential Report must accept that effective investigation may be inhibited. Nevertheless the CAA would rather have a Confidential Report than no report at all.
>
> CAP 382 March 2003

2 FDM and Mandatory Occurrence Reporting

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

2.1 Reporting Standards and Audit Events

FDM 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 FDM analysis, the crews should be encouraged to submit retrospective reports - without prejudice or penalty to the crew concerned.

2.2 Reporting of Issues raised by FDM Events

It would only be in cases of general underlying trends and wider issues when FDM data alone would be used to raise ASRs or MORs. CAP 382 specifically mentions:

> Repetitive arisings at an excessive frequency of a specific type of occurrence which in isolation would not be considered 'Reportable', e.g. GPWS nuisance warnings at a particular airfield.
>
> NOTE: In such cases it is expected that the reporter will submit a single occurrence report together with the supporting evidence of high frequency and/or rate when it is considered that such a situation has been reached. Further reports should be submitted if the situation remains unchanged.

Multiple FDM 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 unstabilised/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 FDM Systems

This chapter deals with the requirements for the maintenance of FDM systems subsequent to the introduction of the FDM 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 despatch.

The new requirements for FDM 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.

1 Equipment Specification

For operators working under JAR-OPS - the EUROCAE Document ED-55* gives the Minimum Operational Performance Specification (MOPS) that "define the requirements to be met in all aircraft required to carry a flight data recorder system **for the purposes of accident investigation.**" While the environmental conditions would not apply in the case of a Quick Access Recorder the other standards relating to the data and other general performance characteristics provide worthy guidance. (*Note that EUROCAE Document ED-112 has been developed to succeed ED-55 but has not yet been accepted by the CAA.)

For operators working under the UK's ANO – Airworthiness Specifications 10 and 10A apply.

The equipment that operators propose to use for FDM should be acceptable to the CAA. The justification submitted may be based on ED-55/ED-112 or another appropriate specification. This equipment should be maintained to an agreed schedule that will meet these requirements.

Clarification of what are mandatory DFDR parameters is in CAP 731 as are the maintenance practices to assure recorder serviceability.

2 Maintaining Equipment Performance

In regard to mandatory recorders, ED-55 states - "The maintenance tasks required to ensure the continued serviceability of the installed flight recorder system will depend on the extent of monitoring 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 FDM.

CAP 731 states – "Article 53 of the Air Navigation Order requires that operators 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, CAP 731 recommends 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. CAP 731 goes on to give guidance on utilising this data, or FDR readouts in general, 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.

3 QAR Serviceability and MELs

When considering an inoperative QAR or equivalent data system, the associated MEL conditions are dependant upon the criticality of the uses to which the data is put. The CAA MMEL Policy on QARs is contained in the MMEL Temporary Revision TR-G6 as shown in Chapter 8 paragraph 7.

Appendix A Terms, Definitions and Abbreviations

1 Definitions

Accident	An unintended event or sequence of events that cause death injury, environmental or material damage.
FDM Event/Exceedence	Circumstances detected by an algorithm looking at FDR data.
FDM 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 organisation and its commitment to achieving safety.
Severity	The potential consequences of a hazard.
System	A combination of physical components, procedures and human resources organised 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.

2 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
ANO (2000)	Air Navigation Order 2000 - Primary UK aviation legislation
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
BALPA	British Airline Pilots Association
BASIS	British Airways Safety Information System - PC system for recording Safety Reports
BCAR	British Civil Airworthiness Requirements - civil code being replaced by JAR-145
CAADRP	Civil Airworthiness Data Recording Programme - CAA-SRG's flight recorder analysis research programme
C of A	Certificate of Airworthiness
DFDR	Digital Flight Data Recorder - normally the crash recorder
DPA	Data Protection Act (UK)
EFIS	Electronic Flight Instrument System
EGT	Exhaust Gas Temperature
FDR	Flight Data Recorder - normally the crash recorder
FLIDRAS	Teledyne FDM analysis software
FMC	Flight Management Computer - aircraft system control computer
FMS	Flight Management System - aircraft control system
FODCOM	CAA Safety Regulation Group's Flight Operations Department Communications. (Information to Industry.)
FOQA	Flight Operational Quality Assurance - FAA's term for flight data monitoring 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 (UK)
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...........
SIDD	Safety Investigation & Data Department - UK CAA Department responsible for Mandatory Occurrence reporting System
SOP	Standard Operating Procedure
SRG	Safety Regulation Group - part of UK CAA responsible for all safety matters
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

Appendix B Typical FDM Exceedence Detection and Routine Parameter Analysis

1 Traditional Basic Operational Event Set

These operational events are typical of those found in most current FDM programs. There have been minor developments over the past 20 years but are basically the same as developed by the CAA's programme with British operators during the late 1970's. However, they still form an excellent starting point for any monitoring programme. (Refer to Chapter 5 Para 7.4)

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 AAL
	08B	Climb out speed high 400 ft AAL to 1000 ft AAL
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)
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

Event Group	Event Code	Description
	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)
Landing Flap	48A	Late land flap (not in position below 500 ft AAL)
	48B	Reduced flap landing
	48D	Flap load relief system operation
Glideslope	56A	Deviation under glideslope
	56B	Deviation above glideslope (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 7.6)

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 a 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 groundspeed 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.
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 monitoring future significant hazards and crew reactions.
Reverse thrust not used on landing	Dependant on operator SOPs.
Auto ground-spoiler not selected for landing	
Landing to shutdown time - more than (x) minutes	Indicates taxiway or stand allocation problems.
Localiser deviation	Excessive or oscillating.
Altitude deviation	Level busts, premature 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 FDM 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.
Powerplant	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
Flight Operations	Take-off and landing weight
	Thrust setting at take-off

Subject Area	Description
	Rotation speed
	Lift-off speed and attitude
	Climbout 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 analysed
	Take-off or landing not analysed
	Bad/non-existent FDR parameters
Fuel Usage	Take-off fuel and Landing fuel
	Taxi-out fuel burn
	Taxi-in fuel burn
	Total fuel burn
	Reserve fuel
	Specific fuel burn
	Cruise fuel burn measurement

Appendix C Sample FDM Procedural and Confidentiality Agreement

This sample agreement is based on a generalised version of a UK operator's agreement that has stood the test of time. It should be understood that there are many different ways of organising FDM programmes and hence many different arrangements. This agreement assumes that an aircrew representative organisation is in place and is taking a pivotal role in communications.

Flight Data Monitoring Agreement

Statement of Understanding between Operator and Aircrew Organisation (AO) or Staff Representative

Dated 1 January 2005

1 Preamble

These notes are intended as guidance to new members of the operator's FDM programme, either operator or AO staff.

It is important to be aware that FDM is but a part, albeit an important one, of the operator's total use of Flight Recorder data. These notes refer specifically to the FDM use of the data.

2 Introduction

It is accepted by both the operator and the AO that the greatest benefit will be derived from FDM by working in a spirit of mutual co-operation 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 FDM should be free to explore new avenues by mutual consent, always bearing in mind that FDM is a safety programme, not a disciplinary one. The absence of rigid rules means that the continued success of FDM depends on mutual trust.

3 Statement of Purpose

3.1 The primary purpose of monitoring operational flight data by the FDM program is to enhance flight safety. The actions to be taken to reverse an adverse trend, or to prevent the repetition of an event, may include raising pilot awareness, changing procedures and/or manuals, and seeking to change pilot behaviour (individually or collectively), amongst others.

3.2 Interested third parties (Manufacturer, Regulator or Research body) may seek access to FDM data for safety purposes.

3.3 If the request is for de-identified data (i.e. the data does not contain any information that would enable the data to be identified as originating from a particular flight), then the operator may supply this information, and will notify the AO representatives on each occasion.

3.4 If, on the other hand, the requested data only has value when it can be linked to specific flights, then the operator will agree with the AO representatives the terms under which the data can be provided.

3.5 Where FDM data is to be used for Continued Airworthiness or other engineering purposes within the company, then secure procedures must be in place to control access to the data. Identification of and contact with crews will not be permitted through this path.

4 Constitution

4.1 The constitution and responsibilities of the Flight Data Monitoring Group are defined in Flight Crew Orders (Detailing working practices and methods). The Group meets once a month. Membership consists of:

Flight Data Monitoring Manager (Meeting Chairman)
A representative from each Fleet's training section
A representative from Flight Data Recording Engineering
A representative from Flight Operations
AO Representatives

4.2 The constitution and responsibilities of the Operational Flight Data Recording Working Group is defined in Flight Crew Orders (Policy, management and longer term matters). The Group meets bimonthly. Membership consists of:

Flight Data Monitoring Manager (Meeting Chairman)
Manager Flight Data Recording Engineering
Aircraft Performance and Operational Representatives
A representative from the Flight Safety Office
AO Representatives

5 Confidentiality

5.1 The operator will not identify flight crew involved in FDM events, except as in 5.1.1, 5.1.2 and 5.1.3 below.

Exceptions:

5.1.1 If the event is reported to the operator in an Air Safety Report. (In which case the FDM group will not investigate the event, provided the ASR relates directly to the FDM event.)

5.1.2 In the case of repeated events by the same pilot in which the FDM group feel extra training would be appropriate.

The AO Representative will invite the pilot to undertake such extra training as may be deemed necessary after consultation with the Fleet manager concerned. The operator will arrange the training.

5.1.3 In other cases of repeated events by the same pilot; or a single pilot-induced event of such severity that the aircraft was seriously hazarded, or another flight would be if the pilot repeated the event.

The AO recognises that, in the interests of flight safety, it cannot condone unreasonable, negligent or dangerous pilot behaviour and, at the operator’s request, will normally consider withdrawing the protection of anonymity.

This consideration by the AO will be undertaken by:

The relevant AO FDM Representative and previously agreed senior members of the AO (e.g. the operator's council chairman).

6 Contact with Pilots

6.1 It is accepted that an FDR trace may give an incomplete picture of what happened, and that it may not be able to explain "why" it happened. The AO Representatives may be asked to contact the pilot(s) involved to elicit further information as to "how" and "why" an event occurred. The AO Representatives may also be asked to contact a pilot to issue a reminder of Fleet or Company policy and/or procedures. In this case the relevant AO Representative will identify and contact the staff concerned.

6.2 In the case of a single event, or series of events, that is judged sufficiently serious to warrant more than a telephone call, but not sufficiently serious to make an immediate application for the withdrawal of anonymity under paragraph 5.1.3, then the AO Representatives will be asked to present the operator's Management view to the crew member(s) concerned, in accordance with the procedure described in **Appendix I**.

6.3 Contact will initially be with the Captain of the flight, but where Human Factors are thought to be involved it may also be necessary to contact the co-pilot or other flight-deck crewmembers.

6.4 It is recognised that the value of the "AO Rep' call" could be demeaned by over-use. Therefore the number of calls, and the value of each, will be monitored by the FDM Group.

6.5 If a pilot fails to co-operate with the AO Representative with regard to the provisions of this agreement, then the operator will receive the AO Representative's approval to assume responsibility for contact with that pilot, and any subsequent action.

Signed on behalf of the Operator

Signed on behalf of the AO Representatives

Appendix I

Procedure to be used when paragraph 6.2 is invoked

- The operator will call upon the AO to arrange for the crew members involved to discuss the event(s) with senior AO personnel.
- The selected AO personnel will possess the following qualifications: a current or recent Base Training appointment with this OPERATOR and a senior elected position within the AO. The operator will be notified of the interviewers before any such interview to confirm their acceptability.
- The AO will provide a written report of each interview to the operator.
- If either the operator or the AO are convinced that, after the interview, the concerns have not been satisfactorily resolved, then the provisions of paragraph 5.1.3. will be invoked.

Appendix D Operators Checklist on FDM Guiding Principles

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

Applicability:

Commercial Air Transportation under JAR-OPS 1 or ANO 2000: From 1 January 2005, 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. (ICAO Annex 6). This process was recommended for all aeroplanes over 20,000 kg with effect from 1 January 2002.

Definition:

Flight Data Monitoring (FDM) 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 Monitoring (FDM) 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 FDM data use.	
2	**Accountability:** The manager of the accident prevention and flight safety programme, which includes the FDM 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 FDM in the AP&FSP manager's responsibilities. 2. Allocation of responsibility for discovery and transmission (normally the FDM Manager). 3. List of managers responsible for action on FDM discovered issues. 4. Agreement with third party to analyse 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 non-standard, unusual or unsafe circumstances occur.	2. Process for deciding if there are changing risks.	
	3. To use the FDM 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.	3. Defines acceptance/Action criteria including the allocation of a measure of severity.	
	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.	4. Process for putting in place remedial action and ensuring it is carried out.	
	5. Confirm the effectiveness of any remedial action by continued monitoring.	5. Process for deciding success/ failure criteria and follow-up actions.	
4	**Flight Recorder Analysis Techniques**		
	1. Exceedence 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.	1. Exceedence 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. All Flights Measurement: A system that defines what is normal practice. This may be accomplished by retaining various snapshots of information from each flight.	2. Set of basic measures from every flight analysed.	

Ref	Objective	Process	Check
	3. Statistics: A series of measures collected to support the analysis process. These would be expected to include the numbers of flights flown and analysed, aircraft and sector details sufficient to generate rate and trend information.	3. Support statistics compiled.	
5	**Flight Recorder Analysis, Assessment and Process Control Tools** The effective assessment of information obtained from digital flight data is dependant 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, visualisation 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 visualisations. 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 utilising 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. 4. Means of informing the regulator of issues.	

Ref	Objective	Process	Check
7	**Accident and Incident Data Requirements** Those specified in JAR-OPS (1.160) take precedence to the requirements of a FDM 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 FDM** Significant risk bearing incidents detected by FDM 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 FDM exceedence 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.	
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.	

Ref	Objective	Process	Check
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 authorised 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 FDM data.	
12	**Conditions of Use and Protection of Participants** The conditions 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	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
	under which the confidentiality may, exceptionally, be withdrawn for reasons of negligence or significant continuing safety concern.		
13	**Airborne Systems and Equipment** Used to obtain FDM 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 FDM 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. Recognise and minimise the effect on the serviceability of mandatory recorders if these are used. 3. Add entry for QAR to Minimum Equipment List.	

Appendix E FDM Programme Costs and Benefits

The following information was taken from CAA FODCOM 30/2002 (December 2002) that includes a Regulatory Impact Assessment for the proposal to introduce FDM.

A FDM 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 FDM programmes have reported substantial cost savings being achieved. These cost saving areas include engines, fuel, maintenance, inspection and hull insurance.

Four of the many UK operators who currently have a FDM programme have provided an estimate of the costs of establishing and running such a programme. The average of these estimates is produced below:

i) Quick Access Recorder (QAR) Cost - £10,000 per unit

ii) QAR Installation costs - £2000 per unit

iii) Decoding hardware and software - £50,000 - £150,000

The ongoing annual cost provided by these operators varies greatly, and appears to be inversely proportional to the fleet size. The annual running cost quoted varies between £4150 per aircraft for a small 10 aeroplane UK operator to £1900 per aircraft for a large UK operator. It should be noted that in spite of these costs this major UK operator's cost benefit analysis still shows an annual saving of £1600 per aircraft.

NOTE: Where an existing DFDR crash recorder is used there may be an 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 FDM 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 FDM 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.

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

4 Potential Benefits

The following examples of where FDM 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 FDM 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 monitoring - automatic rather than manual.
- Warranty support - definitive usage evidence.
- Autoland support - record keeping and system health/accuracy.

Appendix F Examples of the Aircraft Types Covered by ICAO Standards and Recommended Practices on FDM

1 Aircraft Between 20 and 27 tonnes MTOW (Recommendation)

Operators of these aircraft are recommended to have a FDM 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 FDM 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

Appendix G Summary of United Kingdom Flight Data Recorder Requirements

Disclaimer: This table was prepared to help clarify the minimum requirements and should not be used as a definitive document. (Refer to Chapter 8 paragraph 4.)
Note: C of A = Certificate of Airworthiness.

List of Tables included

Table G.1 Type Certificate issued anywhere before 1st April 1971

Weight Group - kg	Typical Aircraft	ANO Scale	JAR-OPS Scale	Notes
5,700 < X ≤ 11,400	Shorts Skyvan	P	1.725: Table A	FDR or CVR
11,400 < X ≤ 27,000	Fokker F27, HS-748	P	1.725: Table A	
27,000 < X ≤ 230,000	Boeing 707, 727, 737-100/200, DC-8, DC-9, BAe 1-11	P	1.725: Table A & Table B params 6-15	Table B applies to a/c first certificated after 30/9/69

Table G.2 Type Certificate issued anywhere on or after 1st April 1971

Weight Group - kg	Typical Aircraft	ANO Scale	JAR-OPS Scale	Notes
5,700 < X ≤ 11,400	Shorts 330	S(i)	1.725: Table A	
11,400 < X ≤ 27,000	ATR 42, Dash 7, Shorts 360	S(ii)	1.725: Table A	
27,000 < X ≤ 230,000	Airbus A300, A310, Boeing 737-300, 757, 767	S(iii)	1.725: Table A & Table B params 6-15	
X > 230,000	Boeing 747 Classic, DC-10, Lockheed L1011-500	S(iii)	As above	Applicable for TC issued **in UK on or after 1/1/70**

Table G.3 Individual Certificate of Airworthiness issued anywhere on or after 1st January 1987 and before 1st January 1989

Weight Group - kg	Typical Aircraft	ANO Scale	JAR-OPS Scale	Notes
5,700 < X ≤ 11,400	BAe Jetstream 32	S(i)	1.725: Table A	
11,400 < X ≤ 27,000	BAe ATP	S(ii)	1.725: Table A	
27,000 < X ≤ 230,000	Airbus A320, Boeing 737-400	S(iii)	1.725: Table A & Table B params 6-15 & if sufficient capacity on FDR: 16-32	
X > 230,000	Boeing 747 Classic, MD-11	S(iii)	As above	Applicable for TC issued **in UK on or after 1/1/70**

Table G.4 Individual Certificate of Airworthiness issued anywhere on or after 1st January 1989 and before 1st June 1990

Weight Group - kg	Typical Aircraft	ANO Scale	JAR-OPS Scale	Notes
5,700 < X ≤ 11,400	BAe Jetstream 41	S(i)	1.725: Table A & if sufficient capacity on FDR: Table B params 6-15b	
11,400 < X ≤ 27,000	ATR 72, BAe ATP	S(ii)	1.725: Table A & if sufficient capacity on FDR: Table B params 6-15b	
27,000 < X ≤ 230,000	Airbus A320, Boeing 737-400	S(iii)	1.725: Table A & Table B params 6-15 and if sufficient capacity on FDR: 16-32	
X > 230,000	Boeing 747 Classic, 747-400, MD-11	S(iii)	As above	Applicable for TC issued **in UK on or after 1/1/70**

Table G.5 Individual Certificate of Airworthiness issued anywhere on or after 1st June 1990 and before 1st April 1998

Weight Group - kg	Typical Aircraft	ANO Scale	JAR-OPS Scale	Notes
5,700 < X ≤ 27,000	CRJ100/200	S(v)	1.720: Table A	
X > 27,000	Avro RJ, A319-340, B737, 777	S(vi)	1.720: Table A & Table B	

Table G.6 Individual Certificate of Airworthiness issued anywhere on or after 1st April 1998

Weight Group - kg	Typical Aircraft	ANO Scale	JAR-OPS Scale	Notes
5,700 < X ≤ 27,000	Bombardier CRJ100/ 200, Embraer EMR-145	S(v)	1.715: Table A1 & if applicable Table C (EFIS)	Also, parameters relating to novel design features
X > 27,000	Bombardier CRJ700, Avro RJ, Airbus A319-340, Boeing 717, 737 NG, 757-300, 777	S(vi)	1.715: Table A1, Table B & if applicable Table C (EFIS)	Also, parameters relating to novel design features

Note: 1) Information contained in these tables is subject to confirmation and is not official.

2) See The Air Navigation Order 2000 for further UK specific information.

3) See NPA OPS-25 Flight Recorder Requirements for further JAA information (including alleviations to JAR-OPS).