ICAO

Doc 10101

Manual on Flight Crew-Machine Interface Recordings

First Edition, 2021

Approved by and published under the authority of the Secretary General

INTERNATIONAL CIVIL AVIATION ORGANIZATION

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AMENDMENTS

Amendments are announced in the supplements to the *Products and Services Catalogue;* the Catalogue and its supplements are available on the ICAO website at www.icao.int. The space below is provided to keep a record of such amendments.

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FOREWORD

Flight data recorders (FDRs) and cockpit voice recorders (CVRs) have been effectively used in accident and incident investigations for a number of years. Considering that many different sources of data are accessed besides flight recorders, it was revealed during many accident investigations that the data from FDRs and CVRs were not sufficient for investigators to fully understand all of the factors that contributed to an accident. It was realized that, while very useful, FDRs and CVRs do not capture all pilot actions and non-verbal communications, such as a crew member pointing to a gauge or screen that is out or fluctuating. In cases where flight crew-machine interface recordings (FCMIRs) have been available, accident investigators have found the information very useful in determining causes/contributing factors and ultimately identifying ways to improve aviation safety. Although there is limited experience with image recorder recordings, image recording systems in lightweight flight recorders have matured over time and now encompass video recordings of the cockpit, recording data link messages (such as controller-pilot data link communications (CPDLC)) and screen capture recordings. The ICAO Council adopted FCMIR provisions in Annex 6 — *Operation of Aircraft*, Part I — *International Commercial Air Transport — Aeroplanes* in 2018. These provisions already required recording data link messages, if the aircraft was so equipped, and now require the recording of information displayed to flight crew from electronic displays as well as the operation of switches and selectors by the flight crew. The use of image recorders in the cockpit was not required due to privacy concerns.

This manual was developed with contribution from subject matter experts and provides States with guidance material for the implementation of appropriate provisions for FCMIRs as required by Annex 6 Part I, Chapter 6, 6.3.4 and provides references to the protections needed for these recordings.

Comments on this manual, particularly with respect to its application and usefulness, are appreciated. These comments will be taken into consideration in the preparation of subsequent editions. Comments concerning this manual should be addressed to:

The Secretary General
International Civil Aviation Organization
999 Robert-Bourassa Boulevard
Montréal, Québec H3C 5H7

GLOSSARY

DEFINITIONS

Balancing test. The determination whereby the competent authority(ies) assesses competing public interests and decides which interest should prevail leading to the determination referred to in Annex 13 — *Aircraft Accident and Incident Investigation*.

Data Quality. Refers to the proportion of data that can be recovered and is not corrupted or inaccurate.

Flight crew-machine interface recording (FCMIR). A function that records information displayed to flight crew as well as switches and controls used by them to operate the aircraft. A recording may comprise one or more types of data such as those captured by image and flight data recorders or other formats appropriate to specific interfaces.

Note.— For the purpose of this definition, flight crew is any licensed crew member charged with duties essential to the operation of an aircraft during a flight duty period.

Flight recorder data download. Means of copying the digital data stored in the crash protected memory module for replay at a later time.

Flight recorder data retrieval. Retrieval of data from the recording medium for the task of presenting the data for analysis purposes.

Flight recorder readout. An analysis of the recorded data from a flight recorder.

Flight recorder replay. The act of reconstructing the recorded situations/scenarios.

Maintenance[1]. The performance of tasks required to ensure the continuing airworthiness of an aircraft, including any one or combination of overhaul, inspection, replacement, defect rectification, and the embodiment of a modification or repair.

Maintenance[2]. The performance of tasks on an aircraft, engine, propeller or associated part required to ensure the continuing airworthiness of an aircraft, engine, propeller or associated part, including any one or combination of overhaul, inspection, replacement, defect rectification, and the embodiment of a modification or repair.

ACRONYMS AND ABBREVIATIONS

AAIB	Air Accident Investigation Branch, United Kingdom
ACAS	Airborne collision avoidance system
AIA	Accident investigation authority
AIR	Airborne image recorder
AIRS	Airborne image recording system
ARTCC	Air route traffic control centre

1. Applicable until 4 November 2020
2. Applicable as of 5 November 2020

BEA	Bureau d'Enquêtes et d'Analyses, France
CAM	Cockpit area microphone
CARS	Cockpit audio recording system
CPDLC	Controller-pilot data link communications
CVR	Cockpit voice recorder
DITS	Digital information transfer system
DL	Data link
DLC	Data link communications
DU	Display unit
EFB	Electronic flight bag
EUROCAE	European Organisation for Civil Aviation Equipment
EGT	Exhaust gas temperature
FCMI	Flight crew-machine interface
FCMIR	Flight crew-machine interface recording
FDR	Flight data recorder
FLIRECSWG	Flight Recorder Specific Working Group of the Flight Operations Panel
FRSMM	Flight Recorder System Maintenance Manual
GCAS	Ground collision avoidance system
GPWS	Ground proximity warning system
HSI	Horizontal situation indicator
HUD	Head-up display
LCD	Liquid crystal display
MOPS	Minimum operation performance specification
ms	milliseconds
ND	Navigation display
NTSB	National Transportation Safety Board, United States
PFD	Primary flight display
QAR	Quick access recorder
RTCA	Radio Technical Commission for Aeronautics
SARP	Standards and Recommended Practices
SSP	State safety programme
TAWS	Terrain awareness warning system
TCAS	Traffic alert and collision avoidance system

PUBLICATIONS

International Civil Aviation Organization (ICAO)

Annex 6 — *Operation of Aircraft*
Part I — *International Commercial Air Transport — Aeroplanes*
Part II — *International General Aviation — Aeroplanes*
Part III — *International Operations — Helicopters*

Annex 13 – *Aircraft Accident and Incident Investigation*

Annex 19 — *Safety Management*

Manuals

Manual of Aircraft Accident and Incident Investigation (Doc 9756)

Safety Management Manual (SMM) (Doc 9859)

Manual on Protection of Safety Information, Part I — *Protection of Accident and Incident Investigation Records* (Doc 10053)

Manual on Location of Aircraft in Distress and Flight Recorder Data Recovery (Doc 10054)

Manual on Flight Recorder System Maintenance (Doc 10104)

OTHERS

United Kingdom Civil Aviation Authority

CAP 762: The Effectiveness of Image Recorder Systems in Accident Investigations
Published on CAA UK website:
http://publicapps.caa.co.uk/modalapplication.aspx?appid=11&mode=detail&id=2527

European Organization for Civil Aviation Equipment (EUROCAE) (www.eurocae.net)

ED-112A — *Minimum Operational Performance Specification for Crash Protected Airborne Systems*
ED-155 — *Minimum Operational Performance Specification for Lightweight Flight Recording Systems*
ED-204A — *Information Security Guidance for Continuing Airworthiness*

RTCA (RTCA.org)

DO-355 – Information Security Guidance for Continuing Airworthiness

Chapter 1

INTRODUCTION

1.1 BACKGROUND

1.1.1 Flight recorders, or “black boxes,” have become synonymous with aircraft accident and incident investigations. The recovery of the flight recorders and subsequent retrieval and analysis of the valuable information stored within the crash-protected memory is widely recognized as a valuable investigation tool, both by the aviation industry and by the general public. Flight recorder information contributes to an effective accident or incident investigation and promotes improvements in safety. The quick access recorder (QAR), as a derivative of the flight data recorder (FDR), is an essential part of flight monitoring systems that improve operational safety and efficiency.

1.1.2 However, the FDR is not the sole component that contributes to the logging of useful information. An FDR system is made up of many components and interconnections with aircraft systems and dedicated sensors. As technology has developed, the ability to record images of the cockpit and capture information displayed to the crew has become easier and more economically viable. Recorded images of the cockpit environment may provide valuable information to accident and incident investigators and contribute to a better understanding of the events leading up to an accident or incident. Image and screen capture recordings also provide investigators insight into what the aircraft presented to the flight crew, what they were dealing with and how they handled the situation.

1.1.3 Eight safety recommendations addressed to ICAO recommended that provisions for the availability of image recordings be included in Annex 6 — *Operation of Aircraft*. The issues leading to these recommendations included the unavailability of data on either the cockpit voice recorder (CVR) or FDR to analyse human performance, a lack of data because no CVR or FDR was installed in the aircraft, and uncertainty about what information was displayed to the flight crew during the event. Examples of such safety recommendation are as follows:

a) France’s Bureau d’Enquêtes et d’Analyses (BEA) has issued five safety recommendations since 1994 on this subject, most notably in the context of the investigation into the Air France flight 447 accident on 1 June 2009;

b) the United States’ National Transportation Safety Board (NTSB) has also proposed and reiterated similar safety recommendations[1]; and

c) in 2016, the United Kingdom’s Air Accidents Investigation Branch (AAIB) reiterated the need for airborne image recorders (AIRs) by recommending the requirement for the installation of cockpit image recorders, in aircraft required to be equipped with FDR and CVR, to capture flight crew actions within the cockpit environment[2].

1.1.4 The purpose of the safety recommendations is to gain information related to the cockpit environment to include non-verbal crew communications, crew workload, and instrument display selections and status, which is not available from FDRs or CVRs. Flight crew-machine interface recordings (FCMIRs), in combination with FDR and CVR recordings, provide a better understanding of the crew’s interactions with the aircraft and its instruments.

1. https://www.ntsb.gov/safety/safety-recs/recletters/A-15-001-008.pdf
2. https://www.gov.uk/aaib-reports/aircraft-accident-report-aar-1-2016-g-wnsb-23-august-2013

Complementarily, image recordings in particular could capture some of these actions and non-verbal communications such as pointing to an object with a finger, a thumb-up as a sign of acknowledgment, or manipulation of a switch, which are not easily accessible or are inaccessible from FDR and CVR recordings.

1.1.5 Many of the crew actions may be derived from FDR recordings by means of the resultant activities of systems on these actions. The recording of the relevant flight crew-machine interface actions makes it possible not only to increase the type of actions being recorded, but also to record those that are not followed by effects on aircraft systems. It is also common to have difficulty identifying some selector noises, especially on modern aircraft where some systems are activated by touch screen selections, using only audio information recorded on a CVR. Recording the flight crew-machine interface assists in clearly identifying the actions performed on selectors, the result of these actions on the aircraft, and a crew member performing the action in the absence of verbalization from the crew.

1.1.6 In addition, crews may be required to manipulate data carriers that are currently not recorded on the FDR. The use of electronic flight bags (EFBs) is difficult to analyse via existing recorders. The FCMIR provisions include the recording of information displayed to the flight crew from installed EFBs to the extent practical.

1.2 OBJECTIVES AND SCOPE

1.2.1 Amendment 43 to Annex 6 — *Operation of Aircraft*, Part I — *International Commercial Air Transport — Aeroplanes*, which introduced provisions for FCMIRs, became applicable on 8 November 2018. The provisions for FCMIRs have an equipage applicability date of 1 January 2023. The objective of this manual is to provide guidance on the implementation of these provisions.

1.2.2 The manual was designed to assist States with the development of an effective and efficient implementation of the FCMIR provisions in Annex 6, Part I, Chapter 6, 6.3.4 and provides:

a) a description of the FCMIR systems;

b) a list of reference material related to these systems, and

c) a collation of FCMIR systems material.

1.3 FLIGHT CREW-MACHINE INTERFACE RECORDING SYSTEM EXPERIENCE

Accident investigation authorities have limited experience of FCMIRs. Examples of issues identified are included in the respective chapters.

1.4 ICAO SARPS REGARDING FLIGHT CREW-MACHINE INTERFACE RECORDINGS

Annex 6, Part I, contains the provisions for FCMIRs. These provisions were introduced into Annex 6, Part I by Amendment 43, in Chapter 6, 6.3.4[3] and refer to Appendix 8 for applications to be recorded.

3. Annex 6, Part I, Amendment 43, applicable on 8 November 2018

Chapter 2

APPLICATIONS TO BE RECORDED

2.1 SCOPE OF THE REQUIREMENTS

2.1.1 According to Annex 6, Part I, Chapter 6, 6.3.4.1, the data to be recorded in the FCMIR is “the information displayed to the flight crew from electronic displays, as well as the operation of switches and selectors by the flight crew.” This means that:

a) the scope is limited to recording the information displayed to the flight crew from electronic displays as well as the operation of switches and selectors by the flight crew. Recording the actions of other crew members (cabin crew, technical crew) or passengers is not in the scope of Annex 6, Part I, Chapter 6, 6.3.4;

b) selections on a touchscreen are not explicitly included in the scope of Annex 6, Part I, Chapter 6, 6.3.4. However, the scope of Annex 6, Part I, Chapter 6, 6.3.4.1 is not limited to physical switches and selectors. When such selections have the same purpose as a switch or selector in a conventional cockpit, the operation of virtual switches and selectors should be recorded;

c) information presented by means of a head-up display or any kind of enhanced flight vision system should be recorded;

d) information displayed or accessible to the flight crew by means other than electronic displays (e.g. information printed on paper) is not in the scope of Annex 6, Part I, Chapter 6, 6.3.4;

e) information available for consultation but not displayed is not in the scope of Annex 6, Part I, Chapter 6, 6.3.4; and

f) similarly, the operation of controls other than switches and selectors (for instance, operation of the control column of flight controls) is not in the scope of Annex 6, Part I, Chapter 6, 6.3.4.

2.1.2 In addition, the scope of Annex 6, Part I, Chapter 6, 6.3.4 is the information needed for the safe operation of the aircraft, as indicated in Annex 6, Part I, Appendix 8, 6. Data from systems not needed for the safe operation of the aircraft and actions not related to the safe operation of the aircraft do not need to be recorded, even though their recording could be beneficial.

2.2 NATURE OF THE INFORMATION TO BE RECORDED

2.2.1 The FCMIR should contain “information displayed to the flight crew from electronic displays,” as indicated below:

a) Annex 6, Part I, Appendix 8, 6.3.1 only prescribes that the information displayed to the flight crew is “captured by sensors or other electronic means.” It does not mean that the FCMIR must contain an exact copy of the pictures displayed by the electronic displays concerned, but that it should provide enough clarity for effective analysis during an investigation.

It should also be noted that capturing displayed information at a much higher rate than what can be perceived by the flight crew is not in the scope of FCMIRs.

b) The focus of Annex 6, Part I, Chapter 6, 6.3.4 is on the displayed information, not on the actual status of the related aircraft systems, which is to some extent already recorded by the FDR parameters. The FCMIR should, for instance, assist in better understanding human-machine interaction issues that contributed to an accident or a serious incident.

c) This implies that the FCMIR is expected to permit an accurate reconstruction of the information displayed to the flight crew from electronic displays, including how it was presented. This accurate reconstruction should be possible without the use of extraordinary means, without data that is likely to be lost during an accident and without requiring test or research.

2.2.2 The FCMIR should also record "the operation of switches and selectors by the flight crew," as indicated below:

a) Annex 6, Part I, Appendix 8, 6.3.1 prescribes that the operation of switches and selectors is "captured by sensors or other electronic means." This does not mean that the FCMIR must contain images of the flight crew when they actuate a switch or selector.

b) Determining which flight crew member actuated a switch or selector is not required, but it is recommended to record sufficient information to make this determination, when practicable.

c) The focus of Annex 6, Part I, Chapter 6, 6.3.4 is on the operation of switches and selectors, not on the command signals received by the concerned aircraft systems. The FCMIR should assist in reconstructing an accurate sequence of operation of switches and selectors and to relate this sequence to the status of aircraft systems and aircrew behaviour:

1) for instance, even if the operation of a switch or a selector has no effect on any aircraft system (e.g. the wrong operation of a switch which is immediately corrected, or a case where transmission of signals to the concerned aircraft system is blocked or delayed), this operation should be recorded and, per Annex 6, Part I, Chapter 6, 6.3.4.3, include timing information so it can be correlated with other information from the CVR and FDR; and

2) this accurate reconstruction should be possible without the use of extraordinary means, without data that is likely to be destroyed during an accident and without requiring test or research.

d) It is expected the FCMIR provides an accurate reconstruction of the operation of switches and selectors in the scope of Annex 6, Part I, Chapter 6, 6.3.4.

2.2.3 According to Annex 6, Part I, Chapter 6, 6.3.4.3, the FCMIR "shall be able to be correlated to the recorded cockpit audio," as outlined below:

a) The correlation should be understood as a time correlation and the "recorded cockpit audio" should be understood as the CVR recording. Indeed, the purpose of Annex 6, Part I, Chapter 6, 6.3.4.3 is to accurately correlate verbal exchanges between flight crew members with the displayed information and flight crew actions to operate the aircraft. This is very helpful to assess crew resource management (CRM) aspects and the influence of human factors, such as fatigue, startle effect, etc.

b) In practice, information needs to be included in the FCMIR that permits synchronizing the FCMIR with the CVR recording.

c) With the FCMIR, an accurate time reconstruction of the information displayed by electronic displays and the operation of switches and selectors is possible with a reasonable amount of technical work. This could, for instance, be achieved by a common time reference for all data sources of the FCMIR.

d) There is no requirement for the FCMIR to have an alternate power source. It is acceptable for the FCMIR to stop while the CVR keeps recording audio.

2.2.4 According to Annex 6, Part I, Appendix 8, 6.3.3, the recording of information displayed to the flight crew shall include, as a minimum:

a) primary flight display (PFD) and navigation display (ND):

1) the intent of recording PFD information is to capture aircraft situational information such as attitude (pitch, roll) indications, horizontal situation indication (from the horizontal situation indicator (HSI)), airspeed indication, vertical speed indication, slip skid indication and indications from the flight director; and

2) the intent of recording ND data is to capture navigation-type information such as routes, waypoints, automatic dependent surveillance — broadcast (ADS-B) IN, traffic advisories from airborne collision avoidance system (TCAS) / traffic collision avoidance system (ACAS) etc., and information about surrounding traffic;

b) aircraft system monitoring displays that display data concerning the status of aircraft systems and their failures. It may also record procedures to be undertaken by the flight crew to address the failure;

c) engine indication displays: display engine parameters, such as revolutions per minute, temperature values, fuel flow and quantity, and oil pressure. Information on hydraulic, pneumatic, electrical and deicing systems may also be captured;

d) traffic, terrain and weather displays:

1) traffic data is typically data from the ACAS / TCAS and includes traffic and resolution advisories;

2) terrain data is typically data on surrounding terrain or terrain ahead, provided by a moving map or a terrain awareness warning system (TAWS) or ground proximity warning system (GPWS); and

3) weather displays typically provide indications of convective weather or windshear from systems such as the airborne weather radar, and may also integrate weather data sent to the aircraft from weather satellites or ground systems;

e) crew-alerting systems displays that provide warnings and cautions to the flight crew;

f) standby instruments, when they are presented by means of electronic displays: these correspond to the minimum set of flight instruments required for instrument flight rules (IFR) operations as prescribed in Annex 6, Part I, Chapter 6, 6.9. Standby instruments usually include an airspeed indicator, altimeter, attitude indicator, turn and slip indicator, magnetic compass, heading indicator (gyroscope), an outside air temperature indicator, indicator of the rate of climb and descent, and a clock; and

g) installed EFBs to the extent it is practical.

2.2.5 Annex 6, Part I, Appendix 8, 6.3.3 provides a minimum list of electronic displays to be recorded on the FCMIR and is not exhaustive. Information needed for the safe operation of the aircraft and displayed to the flight crew by the means of electronic displays other than those listed in Annex 6, Part I, Appendix 8, 6.3.3 should be considered.

2.2.6 It is recognized that on new aircraft types, there may not be a separate display for each of the items listed in Annex 6, Part I, Appendix 8, 6.3.3. What matters is that the information presented by such displays is recorded on the FCMIR.

2.3 CAPTURING COCKPIT INFORMATION USING NEW AND NOVEL SYSTEMS OR DEVICES

2.3.1 New and novel ways are being developed to present pilots with information. This includes systems such as head-up displays (HUDs) and augmented reality devices (sometimes referred to as goggles) or touchscreen, among others.

2.3.2 The system used to capture information provided to the flight crew would need to be adapted to ensure it captures information described in 2.2.4 above. All information provided by these new and novel systems should be recorded, if practical.

Chapter 3

FCMIR PERFORMANCE

Note.— When designing an FCMIR solution, the architecture selected by a manufacturer should limit the loss of information required by an accident investigation authority to interpret what information was presented to the flight crew as well as understanding their actions.

3.1 EXPECTED PERFORMANCE OF THE FCMIR

3.1.1 The data to be recorded should be sampled at a frequency which is commensurate with human capability, such as:

a) when considering the “information displayed to the flight crew from electronic displays,” any information that persists long enough on a display to be perceived and recognized by the flight crew should be captured by the FCMIR; and

b) when considering “operation of switches and selectors,” a sequence of very fast actuations of a switch or selector by a flight crew member should be accurately captured by the FCMIR.

3.1.2 The FCMIR should be designed in a manner that ensures preservation of data including degraded conditions preceding a crash impact. Annex 6, Part I, Chapter 6, 6.3.4.1.1 states the FCMIR system must be crash-protected to ensure, like the FDR and CVR, it survives the post-accident environment. As indicated in Note 5 of Annex 6, Part I, 6.3, specifications for crash-protected flight recorders may be found in the European Organisation for Civil Aviation Equipment (EUROCAE) document ED-112A, Minimum Operational Performance Specification (MOPS) for Crash Protected Airborne Recorder Systems, or equivalent documents.

3.1.3 If image sensors are used, they must be able to capture representative images in all lighting conditions, not just conditions corresponding to the normal operation of the aircraft. If lighting and the cockpit environment allow the flight crew to:

a) read and recognize information displayed on a screen, then it should also be readable on the FCMIR recording; and

b) locate and operate a switch or selector, then the FCMIR recording quality should be such that the switch or selector is recognizable and its position can be determined with certainty.

Momentary loss of discernible information due to a change of lighting or a lightning strike is considered as acceptable.

Documentation

3.1.4 Documentation and information necessary to decode recorded data should be made available to ensure that FCMIR download files can be converted back into information displayed to the flight crew from electronic displays and the sequence of operation of switches and selectors by flight crew. This information could then be made available to operators and accident investigation authorities.

Synchronization

3.1.5 If multiple image sources are used, it should be possible to synchronize them with each other since they must be synchronized with the CVR recordings. Where possible, image recordings should also be synchronized with other airborne recordings.

Duration: start/stop logic

3.1.6 The minimum FCMIR duration should be at least for the last two hours.

3.1.7 Annex 6, Part I, Appendix 8, 6.1 states: “The AIR or AIRS shall start to record prior to the aeroplane moving under its own power and record continuously until the termination of the flight when the aeroplane is no longer capable of moving under its own power.” It is recommended the start-stop logic used by the CVR be used for the FCMIR since this will help ensure synchronization with the CVR.

3.1.8 In addition, depending on the availability of electrical power, the FCMIR should start to record as early as possible during the cockpit checks prior to engine start at the beginning of the flight until the cockpit checks immediately following engine shutdown at the end of the flight.

3.1.9 Although required to record prior to aircraft movement until the aircraft no longer move under its own power, it is recommended that recording begin as soon as the recorder and aircraft systems are powered up.

3.2 COMBINED FLIGHT RECORDERS

3.2.1 Use of a combination recorder, one capable of recording audio (CVR function), data (FDR function), data link (DL function), and flight crew machine interface (FCMIR function) in one self-contained unit are acceptable.

3.2.2 Annex 6, Part I, Chapter 6, 6.3.5.5.2 states:

> “All aeroplanes of a maximum certificated take-off mass of over 15 000 kg for which the application for type certification is submitted to a Contracting State on or after 1 January 2016, and which are required to be equipped with both a CVR and an FDR, shall be equipped with two combination recorders (FDR/CVR). One recorder shall be located as close to the cockpit as practicable and the other recorder located as far aft as practicable.”

When two combination recorders are required, the FCMIR can be integrated into one or both of these devices or installed as a stand-alone dedicated recorder.

3.3 INDUSTRY STANDARDS

3.3.1 The specifications in Sections 1 to 5 of EUROCAE ED-112A (commonly applicable to all types of flight recorders) should be considered.

3.3.2 The ARINC bus standards 429, 717 and 767 should be considered for FCMIRs.

Chapter 4

EXAMPLES OF ARCHITECTURE

4.1 INTRODUCTION

4.1.1 This section provides different examples of systems that can meet the FCMIR requirements in Annex 6, Part I, Chapter 6, 6.3.4. The examples provided here are not meant to be all-inclusive, but instead illustrate some current methods of designing FCMIR systems.

The various system architectures presented in the following sections are:

a) screen capturing;

b) operation of switches and selectors recorded on an FDR; and

c) airborne image recording.

4.1.2 When reviewing the different systems described here, it should be noted these systems could be combined or joined with newer technologies to improve the FCMIR system's capability and better meet the intent of the SARPS.

4.1.2.1 For example, it may be that one image recorder will satisfy several requirements or that several image recorders may be necessary to satisfy one requirement, or a screen-capturing system and an image recorder may be needed to fully address the requirements in Annex 6, Part I, Chapter 6, 6.3.4.

4.2 SCREEN CAPTURING

4.2.1 Screen capturing can be thought of as a video flow recording process of capturing data that is displayed on a screen at a regular rate. It can be seen as successive regularly captured screenshots.

4.2.2 EUROCAE ED112A contains specifications for image recording and can be used when designing a screen capture system. ED112A also contains reference material that can be used to ensure the expected outputs of the system meet the needs of accident investigation authorities.

4.2.3 Screen capture systems may be used to capture information displayed to the flight crew. If the screen capture system does not record the operation of switches and knobs, additional recording systems may be needed.

4.2.4 In normal operation, information on the applications listed in Annex 6, Part I, Appendix 8 should be readable without post-processing of the images. Graphical information such as weather radar and terrain images should be recorded with a resolution to accurately reconstruct the information presented to the flight crew.

4.2.5 Synchronization

If multiple sources are used, they should be synchronized with the CVR system.

4.2.6 Erasure function

4.2.6.1 Screen capture recordings are not considered to contain information with a privacy content, unlike CVR recordings or Class A AIR recordings. For that reason, the requirements applicable to CVR for an erasure function are not necessary.

4.2.6.2 Screen capture recordings should be considered as protected data, similar to FDR recordings. Annex 6, Part I, Chapter 3, 3.3.5 states:

> "As of 7 November 2019, States shall not allow the use of recordings or transcripts of FDR, ADRS as well as Class B and Class C AIR and AIRS for purposes other than the investigation of an accident or incident as per Annex 13, except where the recordings or transcripts are subject to the protections accorded by Annex 19 and are:
>
> a) used by the operator for airworthiness or maintenance purposes;
>
> b) used by the operator in the operation of a flight data analysis programme required in this Annex;
>
> c) sought for use in proceedings not related to an event involving an accident or incident investigation;
>
> d) de-identified; or
>
> e) disclosed under secure procedures.
>
> *Note.— Provisions on the protection of safety data, safety information and related sources are contained in Appendix 3 to Annex 19."*

4.2.6.3 Two architectures for capturing information on electronic displays, video signal splicing and video signal repeating, are presented in the Attachment to this manual.

4.2.7 Existing examples

Video flow recording has already been implemented in air route traffic control centres (ARTCCs) in which data presented to the controllers, and the results of the actions of the controllers (mouse selection, controller-pilot data link communications (CPDLC) incoming/outgoing messages, agenda, etc.), are recorded. Figure 4-1 provides a screen capture image of an ARTCC screen and shows all data displayed to the controller, including drop-down menus and the position of the cursor.

4.3 RECORDING THE OPERATION OF SWITCHES AND SELECTORS ON THE FLIGHT DATA RECORDER (FDR)

4.3.1 When understanding the technical feasibility of recording the operation of switches and selectors in the context of FCMIR systems, it is helpful to note the types of switches and selectors which may be used on a flight deck:

a) Push button: a switch where the user is able to change between two states (e.g. on or off).

b) Selector: a switch where the user is able to select from two or more states via the position of the switch, e.g., position of flaps.

c) Toggle or tumbler: a switch whereby the state is selected by the position of a lever or rocking mechanism, such as a trim switch.

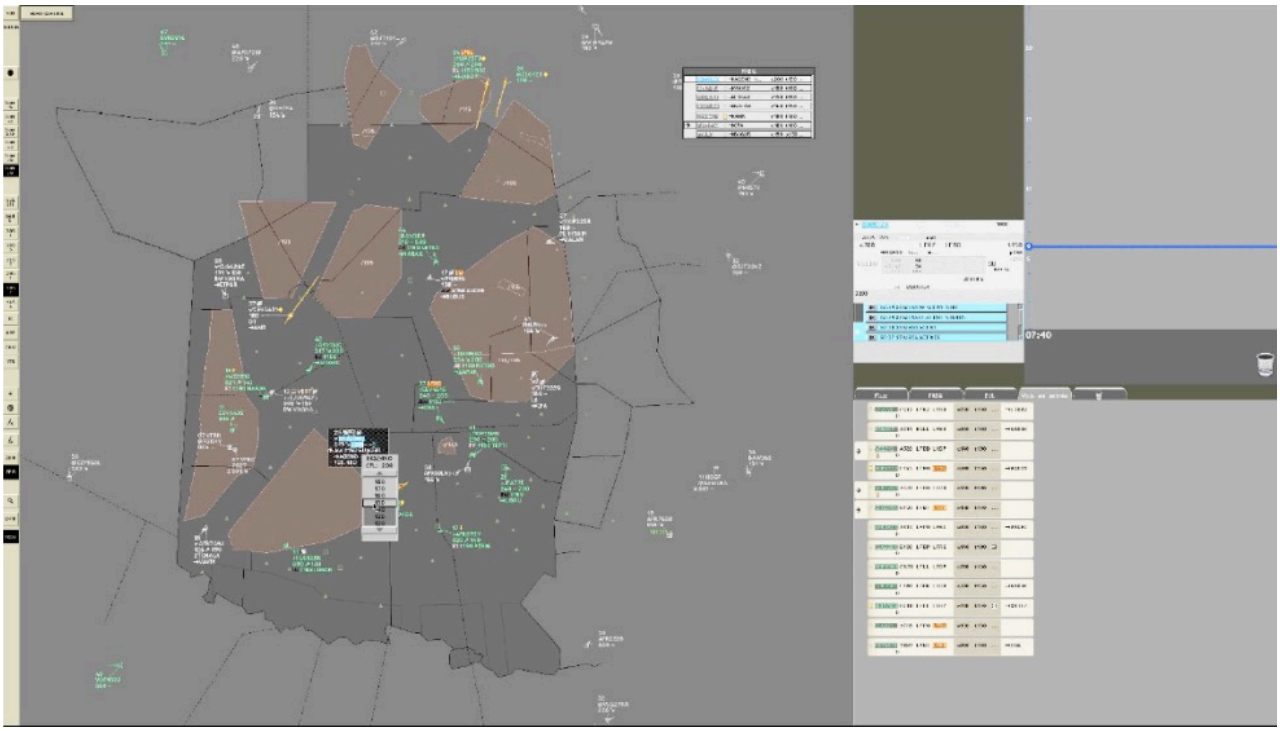

Figure 4-1. ARTCC video flow capture

4.3.2 The operation of switches and selectors can be recorded by the FDR, by using a screen capture method (in the case of virtual switches and selectors) or through the use of an image recorder in the cockpit. In addition, the operation of a switch or selector that produces a distinctive acoustic signature could be recorded by the cockpit area microphone of the CVR.

4.3.3 The above mechanisms can be physical, such as a button next to a screen or a landing gear handle, or virtual, such as touching a “button” on a screen.

4.3.4 Annex 6, Part I, Appendix 8, Table A8-1, on parameter characteristics for flight data recorders, contains requirements to record switch positions by the FDR at rates from 1/4 Hz to 1 Hz. These switches are listed in Table 4-1 below.

Table 4-1. Parameter characteristics for flight data recorders

FDR Parameter #	*PFD Parameter*	*Frequency*
8	Radio transmission keying	1 Hz
15	Autopilot/auto throttle/AFCS mode and engagement status	1 Hz
28	GPWS/TAWS/Ground collision avoidance system (GCAS) status (selection of terrain display mode including pop-up display status) and (terrain alerts, both cautions and warnings, and advisories) and (on/off switch position)	1 Hz

FDR Parameter #	*PFD Parameter*	*Frequency*
32	Landing gear and gear selector position	1/4 Hz
69	De-icing and/or anti-icing systems selection	1/4 Hz
76	Event marker	1 Hz

4.3.5 Using this as a basis, at a minimum, switches recorded by screen capture systems should be recorded at 1/4 Hz or 1 Hz, respectively.

4.3.5.1 Screen-capture requirements are not intended to replace FDR requirements; they are an additional independent requirement. For example, the FDR requirement to record engine temperatures cannot be met by recording the screen displaying engine temperatures to the flight crew because the screen displaying engine temperature may freeze or lock up. It may be acceptable in other instances, such as video recording of the stick shaker.

4.3.6 Push button switch operation and recording

4.3.6.1 For switches and controls recording purposes, there are three attributes associated with a button push.

4.3.6.2 The first attribute is the actual button (or virtual button) press by flight crew, shown in green in row 1 of Figure 4-2. The second attribute is one that can be applied by the button control system. Once the button control system detects a change, it holds the press signal for a specified period of time to ensure it is detected and recorded by the switches and selector recording system. This is shown in blue, in row 2 of Figure 4-2. The third attribute is the actual activation of the system involved, as shown in yellow, in row 3 of Figure 4-2. Figure 4-2 also shows the switches and controls recording interval of 4 Hz, in black, in row 4.

4.3.6.3 Figure 4-2 shows two scenarios to describe how the selector and switch system could work.

4.3.6.3.1 In Scenario 1, a crew member presses a button or virtual button for 200 milliseconds (ms). The button control system detects this event and holds the signal for 500 ms to ensure the button press is detected by the recording system shown in row 4 of Figure 4-2. The system involved switches from an OFF state to ON as is shown in row 3 of Figure 4-2; however due to latency, this action occurs one second after the initial button press by the crew member. In scenario 1, the controls and switches recorder would record a button press for 500 ms and the system activating one second after activation.

4.3.6.3.2 Scenario 2 is similar to Scenario 1; however, in this case the crew member presses the button for 750 ms. Since the event is longer than the 500 ms minimum for the button control system, it records the entire event. Also, the switches and control system would record that the system was already active as is indicated in row 3 of Figure 4-2. In Scenario 2, the switches and control system would record a 750 ms button press and that the system was already active.

4.3.7 Selector, toggle or tumbler switch operation and recording

Using Figure 4-2, toggle and tumbler switches can be seen as ON or OFF as shown in row 3. The selected state of the toggle or tumbler switch is recorded by the switches and selector recording system, but only if the toggle or tumbler switch is activated during a recording interval. For example, a switch could be moved for 200 ms between recording events, or it could be captured if it passed over a time interval that is recorded. A toggle or tumbler switch can have more than two states as well as an invalid state (such as placing the switch between position 2 and 3); if this is possible, the system should be able to distinguish between these states (switch positions).

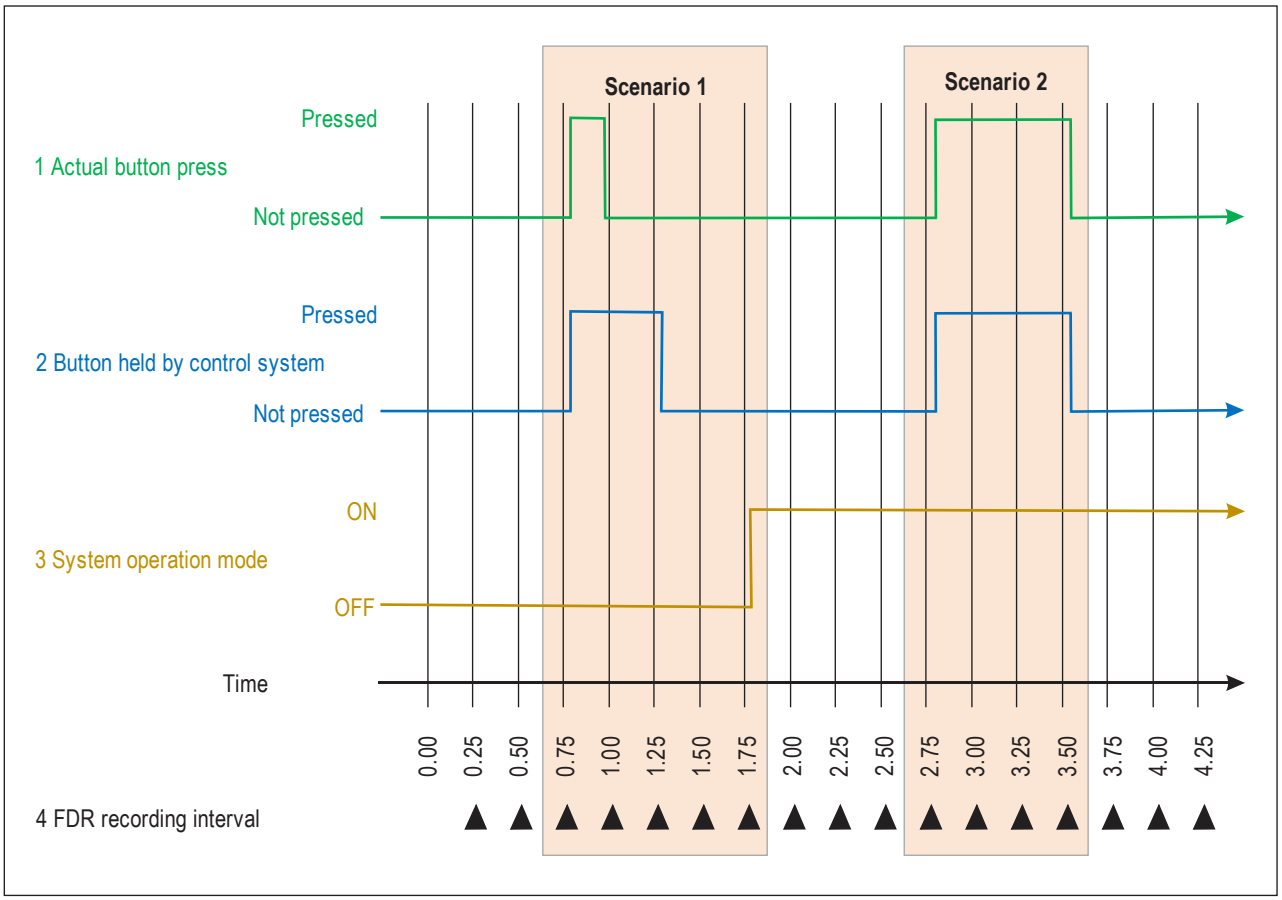

Figure 4-2. Switches and selector recording

4.3.8 Virtual switches

The industry is moving away from dedicated mechanical switches towards virtual switches on electronic displays using display input devices (e.g. cursor control device) and/or a touch interface. Screen capture systems should be designed to record these virtual control devices when they are displayed on the screen.

4.3.9 Use of image recorders to record switches and controls

Operation of switches and selectors may be recorded using an image recorder. This is discussed in section 4.4 below.

4.4 AIRBORNE IMAGE RECORDING: FCMIR USING CAMERA TECHNOLOGY

4.4.1 Existing specifications

Accident investigators have recognized for many years that recorded “images” of the cockpit environment, when available, have proved invaluable in augmenting flight data and audio recordings.

4.4.2 Expected image recorder quality

4.4.2.1 In the event an image recorder is used during normal operation, all required symbols and figures should be readable without post-processing of the images. Graphical information (like weather radar, terrain image) should be recorded with a resolution to accurately reconstruct the information presented to the flight crew.

4.4.2.2 The expected recording quality should be representative of the actual ambient environment, as if an observer was in the cockpit. It is thus expected that information displayed on screens may not be discernible in image recordings if the actual ambient cockpit environment is obscured by fog, smoke, a damaged screen, etc. Degraded image quality due to smoke or fog is acceptable since it provides information about what the flight crew actually saw while working in the cockpit.

4.4.3 Equipment and installation

4.4.3.1 In order to achieve FCMIR requirements, single or multiple camera/image sources can be used and the frame rate and spatial resolution can be adapted from one source to another. Characteristics of the source and the associated recording should be selected to ensure appropriate capture of the required information. It may be that one camera can satisfy several requirements or that several cameras are necessary to satisfy one requirement.

4.4.3.2 When installing image recording systems, care should be given to camera placement to take into account glare and sun reflection.

4.4.4 Erasure function

4.4.4.1 Images of flight crew members are considered to have privacy content. For this reason, the privacy requirements applicable to CVRs should be applied to any image where a body part of a person is likely to appear on the image.

4.4.4.2 Provisions should be made for flight crew to use an erase function after flight. Playback of image recordings by unauthorized persons must be prevented through the use of suitable protection mechanisms. Privacy concerns of image recorders are discussed in more detail in Chapter 5 of this manual and in ED-112A, paragraph III-2.2.7.

4.4.4.3 Annex 6, Part I, Appendix 8, 1.4 d) and Note state:

> "for aeroplanes for which the individual certificate of airworthiness is first issued on or after 1 January 2023, a flight crew-operated erase function shall be provided on the flight deck which, when activated, modifies the recording of a CVR and AIR so that it cannot be retrieved using normal replay or copying techniques. The installation shall be designed to prevent activation during flight. In addition, the probability of an inadvertent activation of an erase function during an accident shall also be minimized.
>
> *Note.— The erase function is intended to prevent access to CVR and AIR recordings by normal replay or copying means, but would not prevent accident investigation authorities access to such recordings by specialized replay or copying techniques."*

4.4.4.4 It would be acceptable to combine the erasure function of airborne image recordings with the CVR erase function. The erasure function should not be offered to the other types of recordings (screen capture, video flow, operation states of switches, etc.).

4.4.4.5 Privacy considerations and protection of sensitive data are discussed in more detail in Chapter 5 of this manual.

4.4.5 Existing examples

Some aircraft manufacturers have already installed FCMIR systems to capture information displayed to the flight crew, interactions between the flight crew and aircraft systems, and the display of weather data.

Chapter 5

PROTECTION OF FLIGHT RECORDER DATA AND TRANSCRIPTS

Image recording data can assist in confirming accident findings by augmenting data from other sources such as the FDR or the CVR. However, potential insights into the causes/contributing factors of an accident must be weighed against the privacy concerns of those involved in the accident. Likewise, proper protection of flight recorder data used for safety management purposes and in routine operations should also be considered.

5.1 CHAPTER OVERVIEW

5.1.1 This chapter discusses the unique flight recorder data protection issues related to camera technology using Class A AIR systems as potential FCMIR solutions. They are defined in Annex 6, Part I, Appendix 8, 6.2. Integrity and availability issues surrounding Class A AIR systems are discussed in Chapter 6 of this manual.

5.1.2 Flight recorder data protection should be understood in the broader context in which it resides.

5.1.3 When an investigation under Annex 13 — *Aircraft Accident and Incident Investigation* is instituted, investigation records are subject to the protections accorded by Annex 13.

5.1.4 Provisions on the protection of flight recorder recordings or transcripts used for purposes of maintaining and improving safety are contained in Appendix 3 to Annex 19 — *Safety Management*.

5.1.5 The use of flight recorder recordings and transcripts in day-to-day operations is governed by Annex 6 — *Operation of Aircraft*.

Note.— Guidance on protection of accident and incident investigation records is provided in the Manual on Protection of Safety Information *(Doc 10053). Guidance on protection of safety data, safety information and related sources is provided in the* Safety Management Manual *(Doc 9859).*

5.1.6 Doc 10053, Chapter 3, 3.1.4 provides that, in agreement with Annex 13, Chapter 5, 5.12.5, the public disclosure of highly sensitive accident and incident investigation records, such as audio content of cockpit voice recordings and image and audio content of airborne image recordings, must be prevented. The objective of preventing the public disclosure of those records is not only for safety enhancement, but also to prevent privacy violation of persons involved and ensuring moral dignity.

5.1.7 In addition, when an investigation has been instituted in accordance with Annex 13, the disclosure or use of cockpit voice recordings and airborne image recordings and any transcripts from such recordings is subject to the administration of the “balancing test.” This requirement applies from the time an accident or incident occurs and continues after the publication of the Final Report. It applies to the entire recordings of the CVR and AIR. Furthermore, it is applicable in any situation, whether the records are in the custody or control of the accident investigation authority or any other entity. In addition, and in accordance with Annex 13, Chapter 5, 5.12.5, audio content of cockpit voice recordings and image and audio content of airborne image recordings must not be disclosed to the public.

5.1.8 The relationship of flight recorder data protection, including Class A AIR data, in various ICAO Annexes is shown in Figure 5-1.

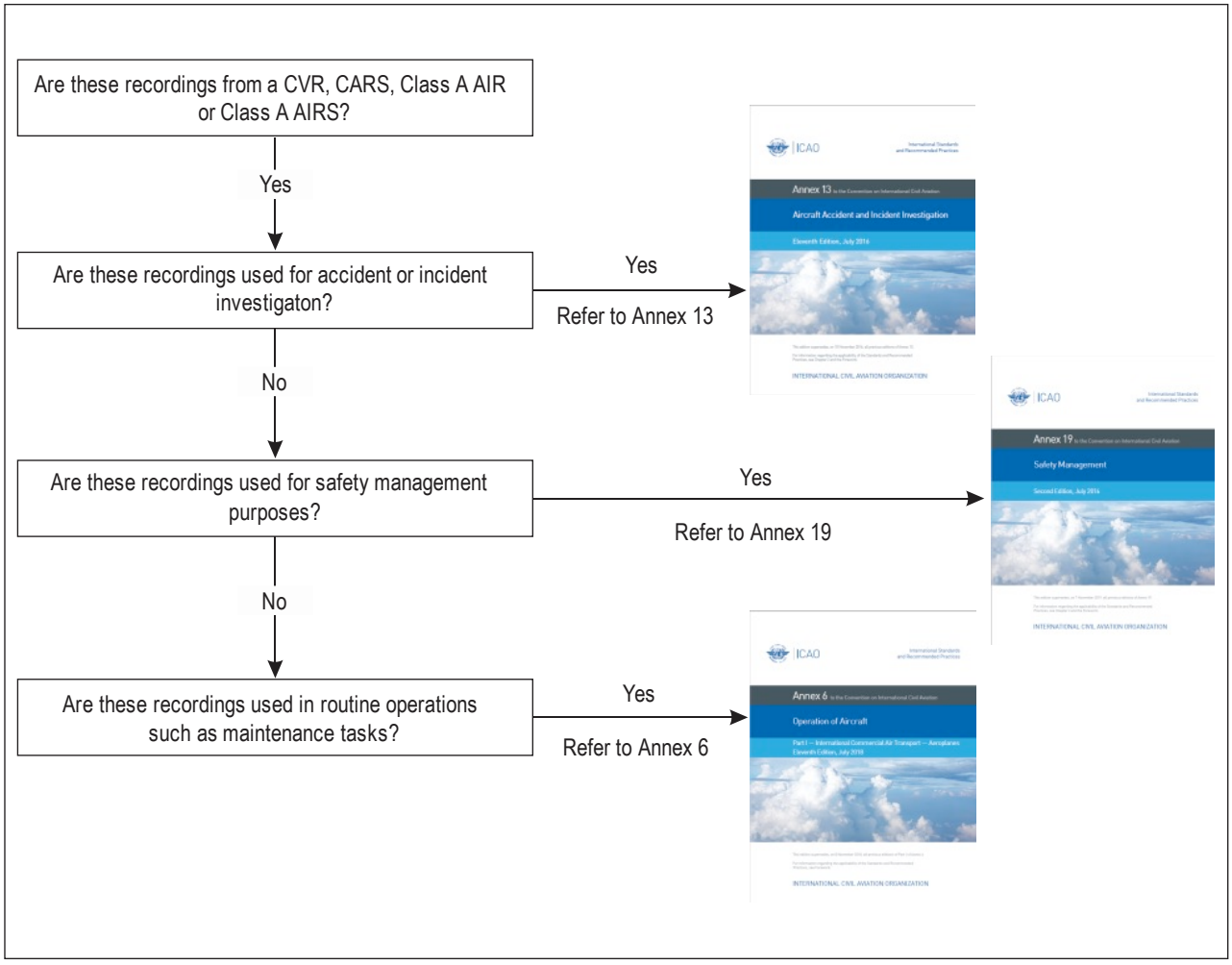

Figure 5-1. Relationship of flight recorder data protection in ICAO Annexes

5.1.9 Protection of image recordings or transcripts consist of four broad areas of concern: confidentiality, privacy, integrity and availability. Confidentiality, protecting the privacy of flight crew, is discussed in this chapter. Data integrity and availability of image data is discussed in Chapter 6 of this manual.

5.1.10 Using the various possible system architectures described in the previous sections of this document, the following must be observed:

a) screen capturing and operation of switches and selectors recordings should be considered as sensitive and afforded the same level of protection as recorded CVR data; and

b) airborne image recordings should be considered as sensitive and afforded the same level of protection as recorded CVR data.

5.1.11 Doc 9859, which is intended to support States implementing effective State safety programmes (SSPs) in accordance with the provisions of Annex 19 — *Safety Management*, requests organizations to ensure only qualified persons collect and store safety data and maintain the competencies needed to process this data. Doc 9859, Chapter 5, 5.1.8 states:

> "Organizations should ensure they have personnel qualified to collect and store safety data, and the competencies needed to process safety data. This usually requires individuals with strong information technology skills as well as knowledge of data requirements, data standardization, data collection and storage, data governance and the ability to understand potential queries that may be needed for analysis. Additionally, the organization should ensure that each SDCPS [safety data collection and processing system] has a designated custodian to apply the protection to safety data, safety information and related sources in accordance with Appendix 3 to Annex 19."

5.1.12 Doc 9859, Chapter 7, 7.7.4 states:

> "Right-to-know laws generally apply to information held by the government. Since most safety data and safety information requiring protection from disclosure is obtained from operational personnel or a service provider, a practical approach would be to allow such data and information to remain with the organization rather than depositing it with a government authority. This way the question of public disclosure does not arise unless some additional government action such as an administrative proceeding is convened. Where the question of public disclosure is faced in an administrative or judicial proceeding, the competent authority should apply the basic principles of protection previously discussed. This approach may not work if service providers are obliged to report safety data and safety information to a government authority, or if the service provider is a governmental authority or agency or part of a governmental authority or agency."

5.1.13 The Radio Technical Commission for Aeronautics (RTCA) DO-355 *Information Security Guidance for Continuing Airworthiness* and EUROCAE ED-204A *Information Security Guidance for Continuing Airworthiness*, Section 2.2.3 recommend implementing physical, logical and organizational measures to aid in the prevention and detection of unauthorized access to software. It is recommended this be applied to not only the software used with storing and retrieving FDR and CVR data, but also to the data itself. Suggested methods include clearly defined roles and responsibilities of a person with access to the data or storage location as well as the use of badges, passwords, digital signatures and locks on the rooms where the data is physically stored. These measures should consider the entire lifecycle of the data and the medium where the data are stored. If used, the expiration of digital signatures while the data are in storage should also be considered.

5.2 FLIGHT RECORDER DATA PROTECTION

5.2.1 Annex 6, Part I, Chapter 3, 3.3.5 states:

> "As of 7 November 2019, States shall not allow the use of recordings or transcripts of FDR, ADRS as well as Class B and Class C AIR and AIRS for purposes other than the investigation of an accident or incident as per Annex 13, except where the recordings or transcripts are subject to the protections accorded by Annex 19 and are:
>
> a) used by the operator for airworthiness or maintenance purposes;
>
> b) used by the operator in the operation of a flight data analysis programme required in this Annex;
>
> c) sought for use in proceedings not related to an event involving an accident or incident investigation;
>
> d) de-identified; or
>
> e) disclosed under secure procedures."

5.2.2 This requirement in Annex 6, Part I, Chapter 3, 3.3.5 includes certain flight crew-machine interface recordings. Image recordings such as Class A AIR data are particularly sensitive since they can record images of flight crew actions.

5.3 USE OF CLASS A AIR DATA

5.3.1 ICAO describes the importance of protecting image recordings in both Annexes 13 and 19. For day-to-day operations, the protection is afforded by Annex 6, Part I, Chapter 3, 3.3.4, which states:

> "As of 7 November 2019, States shall not allow the use of recordings or transcripts of CVR, CARS, Class A AIR and Class A AIRS for purposes other than the investigation of an accident or incident as per Annex 13, except where the recordings or transcripts are:
>
> a) related to a safety-related event identified in the context of a safety management system; are restricted to the relevant portions of a de-identified transcript of the recording; and are subject to the protections accorded by Annex 19;
>
> b) sought for use in criminal proceedings not related to an event involving an accident or incident investigation and are subject to the protections accorded by Annex 19; or
>
> c) used for inspections of flight recorder systems as provided in Section 7 of Appendix 8.
>
> *Note.— Provisions on the protection of safety data, safety information and related sources are contained in Appendix 3 to Annex 19. When an investigation under Annex 13 is instituted, investigation records are subject to the protections accorded by Annex 13."*

5.3.2 If an accident or incident does occur, the protection requirements detailed in Annex 13, Chapter 5, 5.12 and Annex 13, Appendix 2 shall apply. Class A AIR records are considered highly sensitive as they are ambient workplace recordings and shall not be used for purposes other than accident or incident investigations unless certain special conditions are applied. Furthermore, States shall take action to achieve the non-disclosure of image and audio content of airborne image recordings to the public, as per Annex 13, Chapter 5, 5.12.5. The *Manual on Protection of Safety Information* (Doc 10053), Chapter 2, 2.4.2 also acknowledges that disclosure of audio and image recordings violate the privacy of the flight crew and their next of kin if disclosed or used for purposes other than the investigation of an accident or incident in the context of Annex 13.

5.3.3 To protect crew privacy, where camera or video recorders are used, Annex 6, Part I, Appendix 8, 6.3.4 states: "If image sensors are used, the recording of such images shall not capture the head and shoulders of the flight crew members while seated in their normal operating position."

5.3.4 As for safety management purposes, Annex 19, Appendix 3, 3 states:

> "Exceptions to the protection of safety data, safety information and related sources shall only be granted when the competent authority:
>
> a) determines that there are facts and circumstances reasonably indicating that the occurrence may have been caused by an act or omission considered, in accordance with national laws, to be conduct constituting gross negligence, willful misconduct or criminal activity;
>
> b) after reviewing the safety data or safety information, determines that its release is necessary for the proper administration of justice, and that the benefits of its release outweigh the adverse domestic and international impact such release is likely to have on the future collection and availability of safety data and safety information; or

c) after reviewing the safety data or safety information, determines that its release is necessary for maintaining or improving safety, and that the benefits of its release outweigh the adverse domestic and international impact such release is likely to have on the future collection and availability of safety data and safety information.

Note 1.— In administering the decision, the competent authority takes into account the consent of the source of the safety data and safety information.

Note 2.— Different competent authorities may be designated for different circumstances. The competent authority could include, but is not limited to, judicial authorities or those otherwise entrusted with aviation responsibilities designated in accordance with national law."

5.3.5 Annex 19, Appendix 3, 4.2 also refers to public disclosure and states:

"Where disclosure is made in accordance with section 3, States shall ensure that:

a) public disclosure of relevant personal information included in the safety data or safety information complies with applicable privacy laws; or

b) public disclosure of the safety data or safety information is made in a de-identified, summarized or aggregate form."

5.3.6 Based on Annex 6, Part I and Annex 19, it is recommended to de-identify image data by masking distinguishing marks of any persons before releasing such data or information.

5.4 STORAGE AND MAINTENANCE OF CLASS A AIR DATA

5.4.1 Privacy laws vary from State to State. Aircraft operators should be aware of the privacy laws in the State where their aircraft are registered, in the State where the data are stored and the State where routine maintenance is performed.

5.4.2 Airline operators, flight crews, the State of the Operator or the State of the Occurrence of an incident or accident have legitimate concerns regarding the protection of image data. This is because this data could be used for disciplinary purposes, enforcement actions against individuals or the company (except in cases of criminal intent or willful misconduct) and civil litigation. The integrity of any programme that manages image information rests upon protection of the confidentiality of the data.

5.4.3 Disclosure of image data may compromise cooperation in the programme. If operators or personnel perceive the information they provide may be detrimental to them, they may be less apt to provide meaningful or accurate information. For this reason, preventing the misuse of data is of common interest to the operator, the flight crew and the State of the Operator.

5.5 DATA TRANSMITTED FROM THE AIRCRAFT

5.5.1 All flight recorder data transmitted via a radio or satellite link is at risk of being intercepted by unauthorized persons. For this reason, flight recorder data should be protected by technical means, such as encryption, before transmission to ensure it cannot be decoded by unauthorized persons.

5.5.2 Flight recorder data stored in repositories on the ground should also be protected by technical means, such as encryption, to ensure that only authorized persons can gain access to it.

5.5.3 Where operators use image recorders, their operations manual should include relevant procedures for the protection of such recordings and provide information on how it is to be used.

Chapter 6

INTEGRITY AND AVAILABILITY OF DATA

Image recording data can assist in confirming accident findings by augmenting data from other sources such as the FDR or the CVR. The integrity and availability of this data must be protected to ensure the information provided to accident investigators is trustworthy, provided in a timely manner and protects the privacy of persons that were involved in the accident or incident.

6.1 CHAPTER OVERVIEW

Data protection consists of four broad areas of concern: confidentiality, privacy, integrity and availability. This section discusses integrity and availability of data for Class A AIR systems as a potential FCMIR solution. Class A systems are defined in Annex 6, Part I, Appendix 8, 6.2. Confidentiality issues surrounding Class A AIR systems are discussed in Chapter 5 of this manual.

6.2 DATA INTEGRITY AND AVAILABILITY

6.2.1 Class B and Class C AIR systems are defined in Annex 6, Part I, Appendix 8, 6.2 and are the systems that record information shown on the pilots' displays. These systems are considered in this chapter since the confidentiality, integrity and availability concerns for these systems better align with the type of protection needed for FDR and data link communications (DLC) data. Annex 6, Part I, Appendix 8 defines Class B and C AIR or AIRS systems as:

> "6.2.2 A Class B AIR or AIRS captures data link message displays.
>
> 6.2.3 A Class C AIR or AIRS captures instruments and control panels.
>
> *Note.— A Class C AIR or AIRS may be considered as a means for recording flight data where it is not practical or is prohibitively expensive to record on an FDR or an ADRS, or where an FDR is not required."*

6.2.2 Every reasonable effort should be made to protect AIR data. Records and data should be maintained in a form and format that ensures confidentiality, integrity and availability are maintained at all times.

6.3 PROTECTING DATA INTEGRITY

6.3.1 Data from image recording systems can be very helpful to accident investigation teams and should be stored in a manner that minimizes the risk of corruption of the recordings.

6.3.2 If image data are stored on a device with an erase function, the system should be designed to minimize the risk of erasure of the image data during flight, impact or after an accident. Also, if equipped, the probability of an inadvertent activation of an erase function during an accident should be minimized. The erase function may be designed to prevent access to the data using normal download or copying means, but not to prevent accident investigation authorities access to such recordings using specialized download or copying techniques.

6.3.3 Data that are transmitted from the aircraft via a radio or satellite link should be protected from tampering with at least the same level of protection afforded to fixed recording systems.

6.3.4 If compression techniques are used for image recordings, the data should be readily retrievable to an industry standard or non-proprietary format without loss of quality or timing correlation.

6.4 PRESERVING RECORDED DATA

6.4.1 Annex 6, Part I, Chapter 11, 11.6 requires the operator to ensure, to the extent possible, in the event the aeroplane becomes involved in an accident or incident, the preservation of all related flight recorder records and, if necessary, the associated flight recorders, and their retention in safe custody pending their disposition as determined in accordance with Annex 13.

6.4.2 Aircraft owners/operators should document, maintain and protect encryption keys, if used, as well as any serviceability/maintenance information.

6.4.3 Annex 13, Chapter 3, 3.3 states:

> "The State of Occurrence shall take all reasonable measures to protect the evidence and to maintain safe custody of the aircraft and its contents for such a period as may be necessary for the purposes of an investigation. Protection of evidence shall include the preservation, by photographic or other means, of any evidence that might be removed, effaced, lost or destroyed. Safe custody shall include protection against further damage, access by unauthorized persons, pilfering and deterioration.
>
> *Note 1.— Control over the wreckage is dealt with in 5.6.*
>
> *Note 2.— Protection of flight recorder evidence requires that the recovery and handling of the recorder and its recordings be assigned only to qualified personnel."*

6.4.4 Like data stored on traditional recorders, AIR data stored on deployable recorders should prevent disclosure of recordings through technical means, such as encrypting or overwriting, to ensure it cannot be easily downloaded or the images accessed by unauthorized personnel.

6.4.5 The recovery and handling of FCMIR data should only be assigned to qualified and authorized personnel.

6.4.6 Availability of image data may be dependent on the ability of the aircraft to offload this information before the impact. When streaming flight data via a communications link to the ground, either continuously or when triggered, all FDR parameters, CVR, DLR and FCMIR data should be transmitted if possible. Because situations may arise where all flight data types cannot be transmitted to the ground before a crash, image data will have a lower priority than other flight data. The priority in which data should be transmitted from an aircraft is shown in

Table 6-1 and is based on information found in Doc 10054, Chapter 3, 3.6.10.7.

Table 6-1. Doc 10054 Flight data priority scheme

Priority	*When*	*Transmitted flight recorder data*
1	Real time	Required FDR parameters
2	Real time	CVR cockpit area microphone (CAM) audio
3	Historical	Required FDR parameters
4	Real time	CVR crew microphones audio
5	Historical	CVR CAM and crew microphones audio
6	Real time and historical	Data link messages
7		Other data (non-required FDR parameters, AIR)

Chapter 7

ANALYSIS OF DATA

7.1 GENERIC INFORMATION

7.1.1 Specific information on the analysis of recordings in the timeframe of an aircraft accident/incident investigation can be found in the *Manual of Aircraft Accident and Incident* Investigation, Part III — *Investigation* (Doc 9756). An overview of data analysis is provided here.

7.1.2 There are various processes in the readout and analysis of an FCMIR, including the data extraction process and the transcription/analysis process.

7.1.3 FCMIRs are meant to be used for investigation analysis and should be used with the aim of preventing any analytical bias as well as any new analytical bias. It is critical that any analysis of image data be done in association with the CVR, FDR and other recorded information in order to avoid misinterpretation.

Note.— *CAP 762 published by the CAA UK contains lessons-learnt and recommendations about the interpretation of images from an airborne image recorder*.

7.2 DATA EXTRACTION

Data extraction from an FCMI recorder will typically be accomplished using specialized manufacturer software and procedures to communicate with the recorder. The software will typically extract the information recorded and, when necessary, use the proper decompression algorithms to convert the compressed information to usable engineering units and likely industry recognized file formats.

7.3 DATA ANALYSIS

7.3.1 Due to the wealth of information provided by FCMIRs, the analysis can be separated into two broad areas: transcription/description and parametric analysis. Similar to transcribing a CVR, a transcript is usually produced by a group of multi-disciplinary specialists, including image analysis specialists, operations specialists and systems specialists. The purpose of the group is to produce an accurate transcription/description of relevant observed data. This type of data can include visibility information, crew interaction with aircraft systems or each other, and system abnormalities as well as other types of data. The transcription group must take care to use the most objective language and avoid inserting subjective bias into the image description.

7.3.2 Parametric analysis involves using image information to produce a time history of a particular parameter similar to the type of data recorded on an FDR. This may be accomplished manually or with software tools to interpret the values and data types represented by dials, gauges and text on cockpit displays. i.e. engine exhaust gas temperatures (EGTs) or a tuned radio frequency. This data is checked for errors to ensure the automated process was not affected by changing lighting conditions, items temporarily blocking the display or aircraft display settings.

7.3.3 As stated in Chapter 5 of this manual, States should apply considerable protection to FCMIRs that record images in the cockpit. Those reviewing this data should transcribe only relevant information; there is usually no need to transcribe personal information that does not contribute to the investigation. Care must be exercised when transcribing actions or movements of the crew; privacy of the crew and the needs of the accident investigation must also be considered.

7.3.4 Annex 13, Chapter 5 and Doc 9756 contain provisions and guidance pertinent to transcribed recordings and should be considered when including relevant parts of an FCMIR transcript in the final report or its appendices.

———————————

Chapter 8

FCMIR QUALITY AND MAINTENANCE

8.1 A basic overview of maintenance inspection tasks is provided below. These tasks are further described in the *Manual on Flight Recorder System Maintenance (FRSM)* (Doc 10104).

8.2 Similar to other flight recorders, initial and periodic performance and quality inspections may be required to ensure the FCMIR system maintains an acceptable level of quality and continues to perform its intended function throughout its service life. Inspections may include:

a) checking the quality of FCMIR recording at installation;

b) having flight and/or maintenance crew periodically ensure the system is functioning;

c) periodically analysing FCMIR data to ensure recording quality standards are maintained; and

d) preparing and maintaining an inspection report.

8.3 FCMIR manufacturers are required to develop maintenance procedures or instructions for continuing airworthiness aircraft operators to follow that will help detect deficiencies and, if possible, provide remedial actions to return the system to service.

8.4 It would be beneficial for an aircraft operator to have an established procedure to perform a maintenance download and replay of the FCMIR with the intent of highlighting any deficiencies and the associated remedial actions.

8.5 An FCMIR recording inspection should be performed by a technician, hereinafter referred to as an analyst**,** familiar with flight recorders inspection and, in particular, with the new FCMIR functionality. The basic task of the analyst is to check the quality of the recording. If the system quality fails to meet acceptable standards, it would be expected that these noted anomalies would be corrected before returning the system to service.

8.6 FCMIR systems that record images should be inspected to ensure screens and or gauges displayed to the flight crew are readable and flight crew interaction with aircraft systems are discernible. If the quality of the system fails to meet acceptable standards, it would be expected that these noted anomalies would be corrected before returning the system to service.

Attachment A

ARCHITECTURE FOR SCREEN CAPTURING

This attachment provides additional information for the two architectures discussed in section 4.2 of this manual that can be used to capture information on electronic displays, namely, video signal splicing and video signal repeating.

1. VIDEO SIGNAL SPLICING

1.1 This architecture inserts a video splitter between the graphics generator unit and the display unit (DU); one channel goes to the display unit and the other to the flight recorder. This architecture is possible only for display systems that have a graphics generator unit separate from a display unit.

1.2 The aviation industry is combining graphics generation into the display unit, often referred to as a “smart DU.” Smart DUs are common in small aircraft under 7 500 kg and private transport category aeroplanes (business jets), and pose a challenge to this type of architecture.

1.3 The most common video wiring types are coaxial and fibre-optic. Coaxial wiring is typically used with liquid crystal display (LCD) DUs; however, fibre-optic wiring is becoming more prevalent. Splitting a video signal provided by coaxial wiring is similar to splitting television video signals to multiple televisions. Unlike fibre-optic systems, coaxial cable has more degradation over wire length and often cannot tolerate long distances. Fibre-optic wiring offers a significant reduction to wiring weight and reduces installation complexity relative to coaxial wiring. Splitting fibre-optic wiring differs as light waves are used to transmit the video signal. There are passive fibre-optic splitter components available; however, they insert a significant amount of light loss in the overall link budget. The components work off a percentage signal split. In the case of a 60 per cent / 40 per cent splitter, 60 per cent of the light strength is routed to one output and the remaining 40 per cent to the other output. Fibre-optic signals by nature have no degradation of signal strength over long distances; however, signal strength is lost at connectors and wiring breaks. Depending on where the graphics generator units, display units, flight recorders and wiring breaks are located, the fibre-optic signal strength to the DUs or flight recorder could be compromised.

1.4 Aircraft using a bus, such as the ARINC 429 digital information transfer system (DITS), will not be able to “split” the signal and copy one of the channels because of the nature of a video signal. Instead, a video signal must be intercepted and passed on by specialized equipment commonly called a “splitter”. It should be noted that while the name of this device implies the signal is “split,” it is actually captured and then passed on. When considering the use of a DITS splitter, it must be decided if it will be passive or active. A passive splitter does not require power and consists of components that can make one video input into two or more video outputs. An active splitter requires power in order to do the same function as a passive splitter.

1.5 Splitter architecture can accommodate HUD systems, whether the DU is integrated into the display system or is part of a federated system (driven by a separate HUD computer), since HUDs use DU interfaces.

1.6 The role the DU plays in processing graphics data must be considered. There are instances where the DU does little processing beyond unpacking the image data from the graphics generator unit and displaying it. There are other scenarios where the DU may do some image rendering around external video inputs (a video feed is sent direct to a DU instead of going through a graphics generator unit), or some amount of graphics work that for whatever reason could not be done by the graphics generator unit.

1.7 Finally, if there is no graphics generator unit, the smart DU does all the processing and graphics rendering internally, resulting in no external video signal to splice into.

1.8 Video splicing provides the following benefits:

a) video capture for DUs and HUDs is possible;

b) splitters are relatively simple electronic components, easier to purchase and install than flight deck camera equipment; and

c) video splicing could be a suitable retrofit solution.

1.9 Video splicing provides the following challenges:

a) a significant amount of wiring and splitters may be needed depending on how the graphics generator units and DUs are architected. The flight recorder must accommodate multiple video outputs from each graphics generator unit;

b) display system reversion modes need to be considered to ensure that images captured are representative of information displayed to the flight crew for normal and abnormal conditions (e.g. DU failure);

c) the images captured by the flight recorder will not be entirely representative of information displayed to the flight crew when DUs provide some portion of the graphics generation function;

d) splitters are not compatible with a display system employing smart DUs;

e) the addition of splitters introduces failure modes to the display system; and

f) this method does not provide information about the cockpit environment such as smoke, sun glare, etc.

2. VIDEO SIGNAL REPEATING

2.1 The video signal repeating architecture is similar in concept to video signal splicing; however, the splitter work is done internally to the display system to provide dedicated video feeds to the flight recorder.

2.2 This architecture requires the system performing the final graphics rendering for the DU to offer a duplicate “repeater” output sent to the flight recorder.

2.3 A dedicated “repeated” output of the image rendered on the electronic display can be provided to the flight recorder, whether a smart DU, a separate graphics generation unit, or a mixture between the two performs the graphics generation. The bulk of the computing resources are spent rendering the image itself; duplicating the same image on another output is minor in terms of additional complexity and power. This architecture allows the graphics generator unit or DU to always transmit on the same wiring to the flight recorder, regardless of the configuration of the flight deck, and in normal and abnormal conditions. This approach can also be applied to a HUD.

2.4 The wiring needed for video signal repeating depends on the capabilities of the display system. In a display system architecture with smart DUs, the necessary connections would be equivalent to the DUs that require image recording. If a separate graphics generator unit is performing the graphics rendering, the amount of wiring is determined by the number of DUs a graphics generator unit can potentially drive at any given time. For example, if a graphics generator unit can drive three DUs, then three video outputs are required to the flight recorder.

2.5 Depending on the display system architecture and image recording rate, multiple DUs could share the same wiring.

2.6 This architecture provides the following benefits:

a) like video splicing, signal repeating provides the best possible image quality to the flight recorder when compared to flight deck cameras;

b) video capture for DUs and HUDs is possible;

c) the flight recorder would need to accommodate fewer video inputs relative to the video signal splicing architecture; and

d) the architecture is agnostic of the graphics generation location within a display system, and compatible with any DU type (those providing no graphics generation to smart DU).

2.7 This architecture provides the following challenges:

a) video-repeater technology is integral to the display system and is thus suitable only for new aeroplane development, not retrofit; and

b) video-signal repeating does not provide information about the cockpit environment such as smoke, sun glare, etc.

— END —

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