**INTRODUCTION**

**AIRBUS** has made Flight Data Analysis a strategic objective in its effort to promote **Flight Safety**.

The **AIRBUS** approach consists in enhancing the safety of flight operations by **supporting** all our operators to be able to **achieve a high level** of Flight Data Analysis.

The Full Method: ★ Recording  
★ Downloading  
★ Processing  
★ Analysis
Lima FDA Seminar
Presented by Paul DUBOIS
AIRBUS - Airlines SMS & FDA Assistance

RECORDING
RECORDING

HISTORY

VARIOUS RECORDING CHAINS

FRAME - SUBFRAME

PARAMETERS TO BE RECORDED

BEST PRACTICES
World War II:

US National Advisory Committee for Aeronautics (NACA) installed recorders in fighters, bombers and transport aircraft to collect indicated airspeed and load factor data in order to improve structural design.
In the 60’s:

Regulatory authorities mandated the fitting of Flight Data Recorders (FDR) into large commercial aircraft for accident investigation.

Meanwhile, Flight Data Analysis processes were encouraged and sometime requested by authorities.
The 1st FDRs could only engrave **5 parameters** onto a **non-reusable** metal or photographic film:

1) Heading,
2) Altitude,
3) Airspeed,
4) Vertical Acceleration and
5) Time.

1st generation metal foil recorder
Recorders technology then improved significantly from analog to digital on tape, then to **Solid State** able to record over 3,000 parameters.

*2nd generation tape recorder*

*3rd generation Solid State recorder*
Today, while Flight Data Recorders (FDR) or Digital Flight Data Recorders (DFDR) are dedicated to accident investigation, Flight Data Analysis programs extract data from easily accessible Quick Access Recorders (QAR).
RECORDING

HISTORY

VARIOUS RECORDING CHAINS

FRAME - SUBFRAME

PARAMETERS TO BE RECORDED

BEST PRACTICES
VARIOUS RECORDING CHAINS

Sensor -> Analogic-Numeric Converter -> A/C Computer

A/C Computer

ARINC 429 32 bits

FDIU/DMU

ARINC 717 12 bits

*FDIMU: Flight Data Interface and Management Unit

A/C Systems
The **FDIU** (Flight Data Interface Unit) is in charge of picking parameters on the A/C ARINC network.

<table>
<thead>
<tr>
<th>A/C Systems</th>
<th>Data Acquisition &amp; Monitoring Units</th>
<th>Recording Units</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDAC</td>
<td>FDIU</td>
<td>DFDR/SSFDR</td>
<td>DFDR Data</td>
</tr>
<tr>
<td>DMC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FWC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FCDC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BSCU</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DFDR/SSFDR**: Digital/Solid State Flight Data Recorder

**Crash Recording Chain**
VARIOUS RECORDING CHAINS

The FDIU provides the same Data to the DFDR and to a QAR LRU. This is the minimum equipment in order to be able to have an FDA program.

Minimum for an FDA Program

Data

DFDR Data

QAR Data (=DFRD Data)
VARIOUS RECORDING CHAINS

**DAR** Data stands for **Digital ACMS Recorder Data**
**DAR** Data and **QAR** Data are used for FDA program.

![Diagram showing various recording chains with A/C Systems, Data Acquisition & Monitoring Units, Recording Units, and Data sections.]

- **A/C Systems**: SDAC, DMC, FWC, FCDC, BSCU, All A/C Systems
- **Data Acquisition & Monitoring Units**: FDIU, DMU
- **Recording Units**: DFDR/SSFDR, QAR LRU
- **Data**: DFDR Data, DAR Data, SAR Data, ACMS Reports
A DMU can be programmed by the operator in order to record any convenient parameters (e.g.: FDA, Maintenance or Fuel Monitoring, ...) provided they are available on the ARINC network.

But FDIU is not programmable by the operator.
**VARIOUS RECORDING CHAINS**

**FDIU** and **DMU** are often combined into a single equipment: **FDIMU**
**FDIU** and **DMU** are often combined into a single equipment: **FDIMU**

In that case **both QAR and DAR data can be recorded** on the same media.
VARIOUS RECORDING CHAINS

FDIU and DMU are often combined into a single equipment: FDIMU. In that case, both QAR and DAR data can be recorded on the same media.
VARIOUS RECORDING CHAINS

Digital ACMS Recorder (DAR)
Optional - Recording with Customized Frame for FDAP and/or for Maintenance or Fleet Monitoring

Digital Flight Data Recorder (DFDR)
Mandatory Recording with Frozen Frame for Accident Investigation

Quick Access Recorders (QAR)
Optional - Copy of DFDR for the FDAP
RECORDING

HISTORY

VARIOUS RECORDING CHAINS

FRAME - SUBFRAME

PARAMETERS TO BE RECORDED

BEST PRACTICES
Either the FDIU or the DMU sends continuous Data Blocks containing 4 seconds of flight Parameters. One block is called a frame.

Data Stream

FRAME X

FRAME X + 1

FRAME X + 2

1s 1s 1s 1s

SUBFRAME SUBFRAME SUBFRAME SUBFRAME

16 32 64 128 256 512

Usually from 64 up to 1024 Word Per Second
WORDS are numbered from the beginning to the end of the SUBFRAME…
Each word is made of 12 bits

These bits contain the active parameter data

One word can contain several parameters
The stream is managed by synchronisation words and a data frame counter which provide the continuous assessment capability on the stream.
Parameters are stored in a word or in a portion of word. Depending on the parameter refresh rate, it can be stored several times in one frame.

**FRAME 253**

- **SF 1**
- **SF 2**
- **SF 3**
- **SF 4**

**PITCH ATTITUDE**

From bit 4 to bit 12

**4 Hz**

Word 32

Word 48

Word 64

Word 80

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FRAME - SUBFRAME

Data Stream

FRAME 252

FRAME 253

FRAME 254

2 Hz PARAMETER

4 Hz PARAMETER
RECORDING

HISTORY

VARIOUS RECORDING CHAINS

FRAME - SUBFRAME

PARAMETERS TO BE RECORDED

BEST PRACTICES
Regulations on parameters to be recorded only concern the DFDR. These regulations also affect the QAR data because it’s a copy of DFDR. These regulations are:

1. ICAO - Annex 6 Part I - Aereoplanes - Chapter 6 Para 6.3 - Appendix 8

<table>
<thead>
<tr>
<th>Serial number</th>
<th>Parameter Description</th>
<th>Measurement Range</th>
<th>Maximum sampling and recording interval (seconds)</th>
<th>Accuracy limit (sensor must compare to FDR, read-out)</th>
<th>Recording resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Time (UTC when available, otherwise relative time count or GPS time UTC)</td>
<td>24 hours</td>
<td>4</td>
<td>±0.125% per hour</td>
<td>1 second</td>
</tr>
<tr>
<td>2</td>
<td>Pressure-altitude</td>
<td>-390 m (-1 000 ft) to maximum certified altitude of aircraft +1 500 m (+5 000 ft)</td>
<td>1</td>
<td>±3 m to ±200 m (=100 ft to +700 ft)</td>
<td>1.5 m (5 ft)</td>
</tr>
<tr>
<td>3</td>
<td>Indicated airspeed or calibrated airspeed</td>
<td>91 km/h (56 kts) to max V_{MA} (V_{S} to 1.3 V_{MA} (Note 1))</td>
<td>1</td>
<td>±5%</td>
<td>1 kt (0.5 kt recommended)</td>
</tr>
<tr>
<td>4</td>
<td>Heading (primary flight crew reference)</td>
<td>360°</td>
<td>1</td>
<td>±1°</td>
<td>0.5°</td>
</tr>
<tr>
<td>5</td>
<td>Normal acceleration (Note 2)</td>
<td>-1 g to +6 g</td>
<td>0.115</td>
<td>±1% of minimum range excluding</td>
<td>0.004 g</td>
</tr>
<tr>
<td>6</td>
<td>Pitch attitude</td>
<td>±75° or usable range whichever is greater</td>
<td>0.25</td>
<td>±2°</td>
<td>0.5°</td>
</tr>
<tr>
<td>7</td>
<td>Roll attitude</td>
<td>±180°</td>
<td>0.25</td>
<td>±2°</td>
<td>0.5°</td>
</tr>
<tr>
<td>8</td>
<td>Radio transmission keying</td>
<td>On-off (one discrete)</td>
<td>1</td>
<td>±5%</td>
<td>0.2% of full range or the resolution required to operate the aircraft</td>
</tr>
<tr>
<td>9</td>
<td>Power on each engine (Note 4)</td>
<td>Full range</td>
<td>1 (per engine)</td>
<td>±5%</td>
<td>0.2% of full range or the resolution required to operate the aircraft</td>
</tr>
<tr>
<td>10</td>
<td>Trailing edge flap and cockpit control selection</td>
<td>Full range or each discrete position</td>
<td>2</td>
<td>±5% or ±160° as pilot’s indicator</td>
<td>0.5% of full range or the resolution required to operate the aircraft</td>
</tr>
<tr>
<td>11</td>
<td>Leading edge flap and cockpit control selection</td>
<td>Full range or each discrete position</td>
<td>2</td>
<td>±5% or ±160° as pilot’s indicator</td>
<td>0.5% of full range or the resolution required to operate the aircraft</td>
</tr>
<tr>
<td>12</td>
<td>Thrust reverser position</td>
<td>Stowed, in transit, and reverse</td>
<td>1 (per engine)</td>
<td>±2% unless higher accuracy uniquely required</td>
<td>0.2% of full range</td>
</tr>
<tr>
<td>13</td>
<td>Ground speed/zero speed (selection and position)</td>
<td>Full range or each discrete position</td>
<td>1</td>
<td>±7°C</td>
<td>0°C</td>
</tr>
<tr>
<td>14</td>
<td>Outside air temperature</td>
<td>Sensor range</td>
<td>2</td>
<td>±7°C</td>
<td>0°C</td>
</tr>
<tr>
<td>15</td>
<td>Autopilot/auto throttle AFCU data and engagement status</td>
<td>A suitable combination of disconnects</td>
<td>1</td>
<td>±7°C</td>
<td>0°C</td>
</tr>
<tr>
<td>16</td>
<td>Longitudinal acceleration (Note 2)</td>
<td>±1 g</td>
<td>0.25</td>
<td>±0.015 g, excluding a current error of ±0.05 g</td>
<td>0.004 g</td>
</tr>
<tr>
<td>17</td>
<td>Lateral acceleration (Note 2)</td>
<td>±1 g</td>
<td>0.25</td>
<td>±0.015 g, excluding a current error of ±0.05 g</td>
<td>0.004 g</td>
</tr>
</tbody>
</table>

Note: The preceding 16 parameters satisfy the requirements for a Type II FDR.
Regulations on parameters to be recorded only concern the DFDR. They also affect the QAR data because it’s a copy of DFDR. These regulations are:

1. ICAO - Annex 6 Part I - Aereoplanes - Chapter 6 Para 6.3 - Appendix 8
2. EASA - AIR OPERATIONS - Commercial Air Transport

**AMC2 CAT.IDE.A.190 Flight data recorder**

Operational performance requirements for aeroplanes first issued with an individual COFA on or after 1 April 1998 and before 1 January 2016

(a) The operational performance requirements for FDRs should be those laid down in EUROCAE Document ED-55 (Minimum Operational Performance Requirements For Flight Data Recorder Systems) dated May 1990, or EUROCAE Document ED-112 (Minimum Operational Performance Specification for Crash Protected Airborne Recorder Systems) dated March 2003, including amendments n°1 and n°2, or any later equivalent standard produced by EUROCAE.

<table>
<thead>
<tr>
<th>No.</th>
<th>Parameter</th>
<th>Range</th>
<th>Sampling interval in seconds</th>
<th>Accuracy limits (sensor input compared to FDR readout)</th>
<th>Recommended resolution in readout</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Time</td>
<td>24 hours</td>
<td>4</td>
<td>± 0.125 % per hour</td>
<td>1 second</td>
<td>(a) UTC time preferred where available.</td>
</tr>
<tr>
<td>6</td>
<td>Pitch attitude</td>
<td>±75 degrees</td>
<td>0.25</td>
<td>±2 degrees</td>
<td>0.5 degrees</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Roll attitude</td>
<td>±180 degrees</td>
<td>0.5</td>
<td>±2 degrees</td>
<td>0.5 degrees</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Manual radio transmission keying</td>
<td>Discrete</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>Preferably each crew member but one discrete acceptable for all transmissions provided that the replay of a recording made by any required recorder can be synchronised in time with any other required recording to within 1 second.</td>
</tr>
<tr>
<td>9a</td>
<td>Propulsive thrust / power on each engine</td>
<td>Full range</td>
<td>Each engine each second</td>
<td>±2 %</td>
<td>0.2 % of full range</td>
<td>Sufficient parameters e.g. EPR/To, Torque/NT as appropriate to the particular engine must be recorded to determine power in both normal and reverse thrust. A margin for possible overspeed should be provided.</td>
</tr>
<tr>
<td>9b</td>
<td>Flight crew compartment thrust / power lever position</td>
<td>Full range</td>
<td>Each lever each second</td>
<td>±2 % or sufficient to determine any gated position</td>
<td>2 % of full range</td>
<td>Parameter 9b must be recorded for aeroplanes with non-mechanically linked cockpit-engine controls, otherwise recommended.</td>
</tr>
</tbody>
</table>

**Table 1: FDR**

**AMC3 CAT.IDE.A.190 Flight data recorder**

Performance specifications for the parameters to be recorded for aeroplanes first issued with an individual COFA on or after 1 April 1998 and before 1 January 2016.
## PARAMETERS TO BE RECORDED

### TABLE II-A.1: PARAMETERS TO BE RECORDED - AEROPLANES

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Time</td>
<td>24 hours</td>
<td>4</td>
<td>± 0.125% per hour</td>
<td>1 second</td>
<td><em>(a) UTC time preferred where available.</em></td>
</tr>
<tr>
<td>1b</td>
<td>Relative Time Count</td>
<td>0 to 4095</td>
<td>4</td>
<td>± 0.125% per hour</td>
<td></td>
<td><em>(b) Counter increments each 4 seconds of system operation.</em></td>
</tr>
<tr>
<td>1c</td>
<td>GPS Time Sync</td>
<td>Discrete</td>
<td>4</td>
<td></td>
<td></td>
<td><em>(c) To establish whether the aircraft clocks are synchronised to GPS time.</em></td>
</tr>
<tr>
<td>2</td>
<td>Pressure Altitude</td>
<td>- 1 000 ft to maximum certificated altitude of aircraft + 5 000 ft</td>
<td>1</td>
<td>±100 ft to ±700 ft</td>
<td>5 ft</td>
<td>Refer to paragraph II-A 6.1</td>
</tr>
<tr>
<td>3</td>
<td>Indicated Airspeed or Calibrated Airspeed</td>
<td>50 kt or minimum value from installed pitot static system to Max $V_{\text{oe}}$ Max $V_{\text{oe}}$ to 1.2 $V_{\text{oe}}$</td>
<td>1</td>
<td>± 5%</td>
<td>1 kt (0.5 kt recommended)</td>
<td>Refer to paragraph II-A 6.1</td>
</tr>
<tr>
<td>4</td>
<td>Heading (Primary flight crew reference)</td>
<td>0 - 360 degrees and discrete ‘true’ or ‘mag’</td>
<td>1</td>
<td>± 2 degrees</td>
<td>0.5 degrees</td>
<td>When true or magnetic heading can be selected, the primary heading reference, a discrete indicating selection shall be recorded.</td>
</tr>
<tr>
<td>5</td>
<td>Normal Acceleration</td>
<td>- 3 g to + 6 g</td>
<td>0.125</td>
<td>± 0.09 g excluding a datum error of ±0.45 g</td>
<td>0.004 g</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Pitch Attitude</td>
<td>± 90 degrees</td>
<td>0.25</td>
<td>± 2 degrees</td>
<td>0.5 degrees</td>
<td>Accuracy will only apply within ±75° range</td>
</tr>
<tr>
<td>7</td>
<td>Roll Attitude</td>
<td>± 180 degrees</td>
<td>0.5</td>
<td>± 2 degrees</td>
<td>0.5 degrees</td>
<td>For a new aircraft type, an analysis should be performed by the aircraft manufacturer in order to assess if a shorter sampling interval is necessary to capture quick attitude variations in a dynamic sequence.</td>
</tr>
<tr>
<td>8</td>
<td>Manual Radio Transmission Keying and CVR/FDR synchronization reference</td>
<td>Discrete(s)</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>Preferably each crew member but one discrete acceptable for all transmissions provided the CVR/FDR system complies with paragraph 2-1.11 of Section 2 (including ATC/SATCOM communications)</td>
</tr>
</tbody>
</table>
PARAMETERS TO BE RECORDED

Regulations on parameters to be recorded only concern the DFDR. They also affect the QAR data because it's a copy of DFDR. These regulations are:

1. **ICAO - Annex 6 Part I - Aereoplanes - Chapter 6 Para 6.3 - Appendix 8**
2. **EASA - AIR OPERATIONS - Commercial Air Transport**
   AMCCAT.IDE.A.190 Flight Data Recorder
3. **EUROCAE - MOPS for Crash Protected Airborne Recorder Systems**
   ED-55 / ED-112 / ED-112 A
4. **FAR 121.334 Digital Flight Data Recorders**
   Appendix M to Part 121 - Airplane Flight Recorder Specifications
PARAMETERS TO BE RECORDED

Regulations on parameters to be recorded only concern the DFDR. They also affect the QAR data because it's a copy of DFDR. These regulations are:

1. ICAO - Annex 6 Part I - Aereoplanes - Chapter 6 Para 6.3 - Appendix 8
2. EASA - AIR POERATIONS - Commercial Air Transport
   AMC CAT.IDE.A.190 Flight Data Recorder
3. EUROCAE - MOPS for Crash Protected Airborne Recorder Systems
   ED-55 / ED-112 / ED-112 A
4. FAR 121.334 Digital Flight Data Recorders
   Appendix M to Part 121 - Airplane Flight Recorder Specifications

Airbus adds to these lists, parameters also required by Airbus Flight Safety and Airbus Handling Quality. They are Mandatory parameters identified by an M. (M06a = Pitch Attitude)
On the DFDR data frame there are also parameters recorded on request of Airbus internal stakeholders. They are called **Documentary Parameters**.

D09 = Vertical Speed

This parameter is not required by regulations but could be very useful for an FDA software.
For the DAR Data Frame there is no regulatory requirement but most of the previous parameters (Mandatory and Documentary) are recorded.

For DAR the **Frame is defined by the operator**.

Any modifications will obviously affect the final picture we could have of a flight.
RECORDING

HISTORY

VARIOUS RECORDING CHAINS

FRAME - SUBFRAME

PARAMETERS TO BE RECORDED

BEST PRACTICES
Frame definition must be known by the operator

When customization (DAR Data)
- Must be traced
- Relevant parameter
- Relevant source
- Relevant sampling rate
- Must be adapted to the frame capacity

Other use of the data must not prejudice the FDAP use
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