

Lima FDA Seminar

Presented by Paul DUBOIS

AIRBUS - Airlines SMS & FDA Assistance

Flight Data Analysis

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.

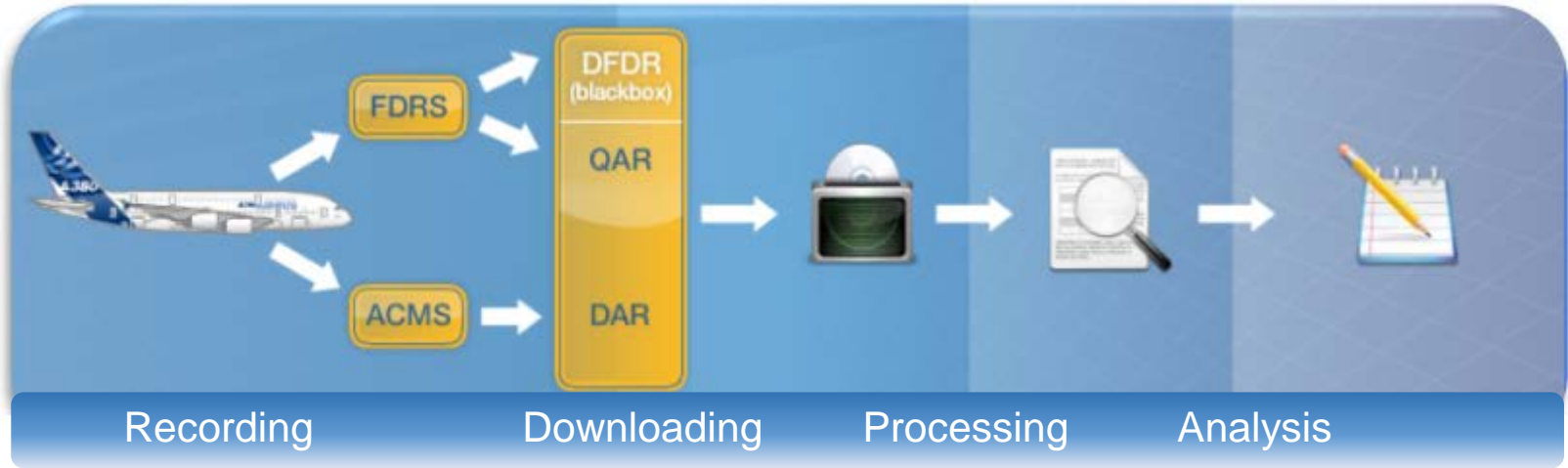
The Full Method:

- ★ Recording
- ★ Downloading
- ★ Processing
- ★ Analysis

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RECORDING

INTRODUCTION



Recording Systems

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

HISTORY



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**

HISTORY

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.



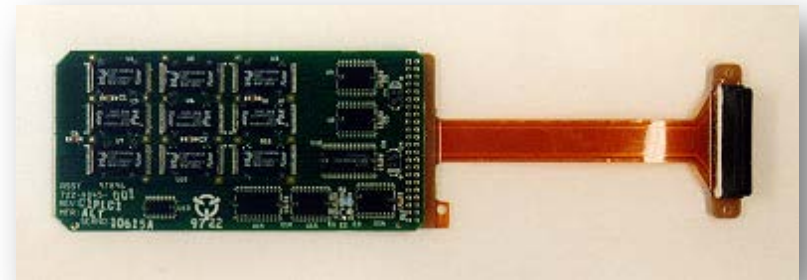
1st generation metal foil recorder

HISTORY

Recorders technology then improved significantly from analog to digital on tape, then to **Solid State** able to record over **3 000 parameters**.

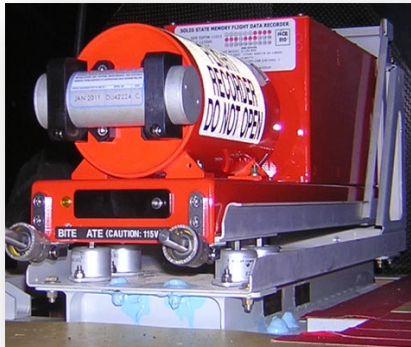


*2nd generation
tape recorder*



*3rd generation
Solid State recorder*

HISTORY



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

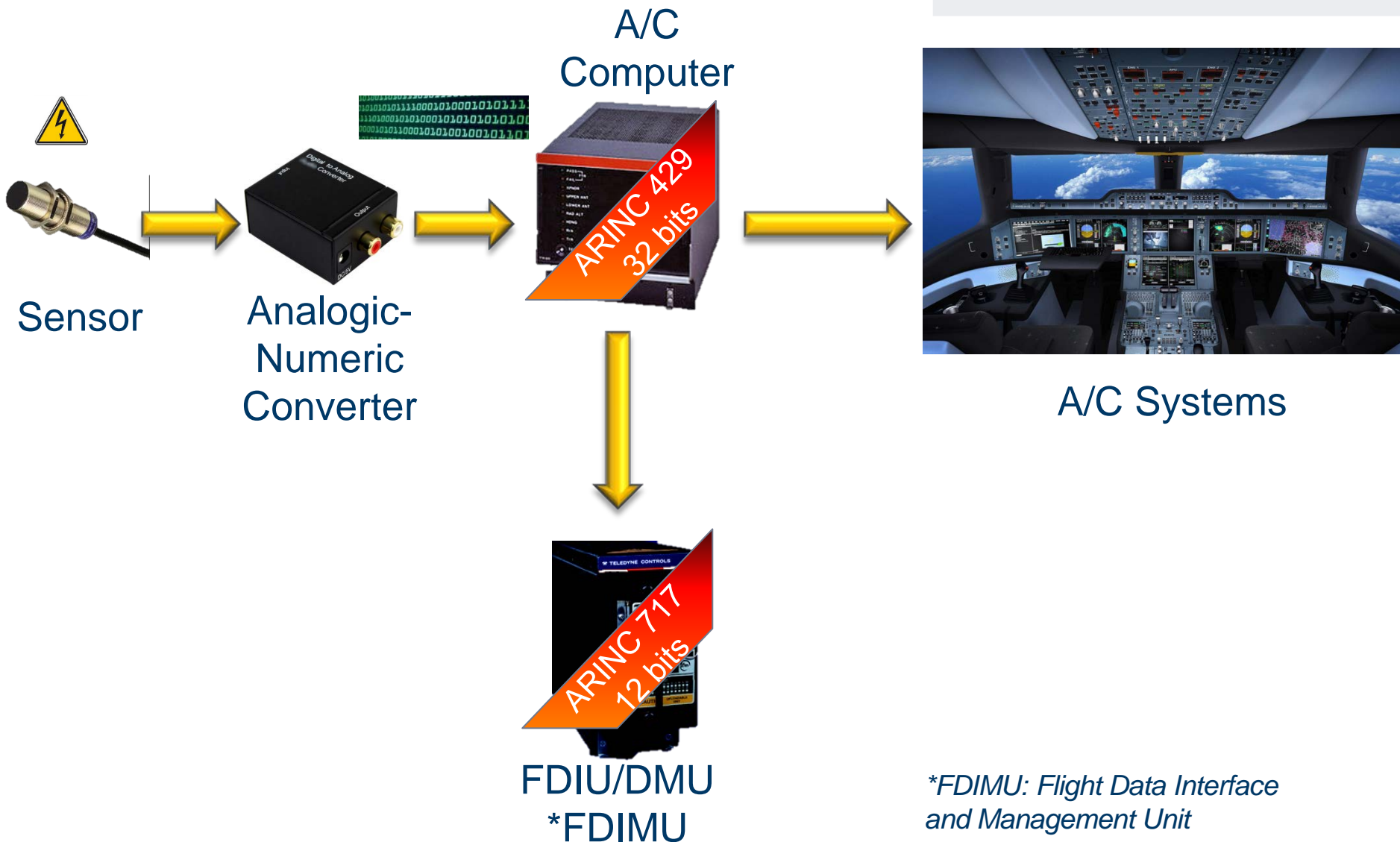
VARIOUS RECORDING CHAINS

FRAME - SUBFRAME

PARAMETERS TO BE RECORDED

BEST PRACTICES

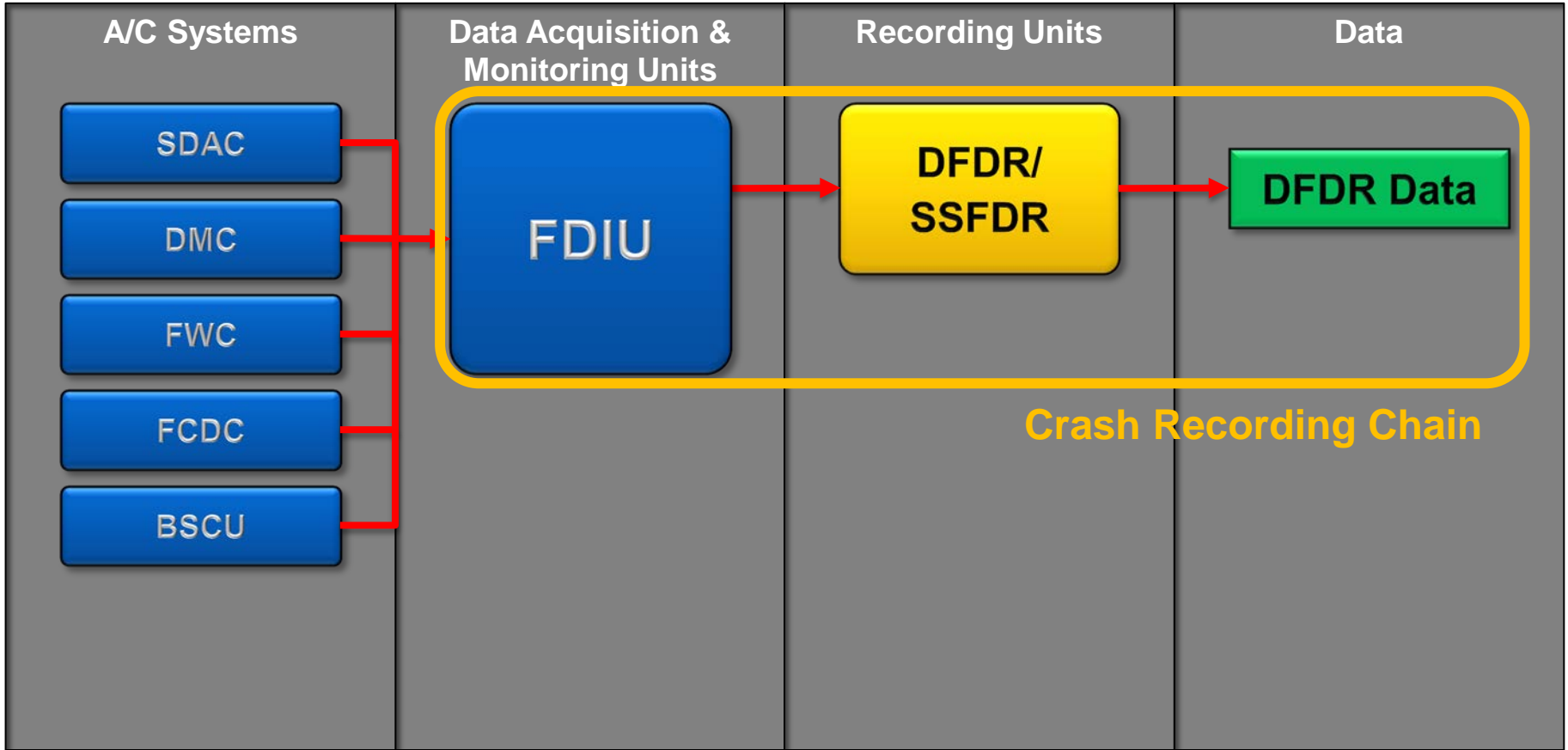
VARIOUS RECORDING CHAINS



**FDIMU: Flight Data Interface and Management Unit*

VARIOUS RECORDING CHAINS

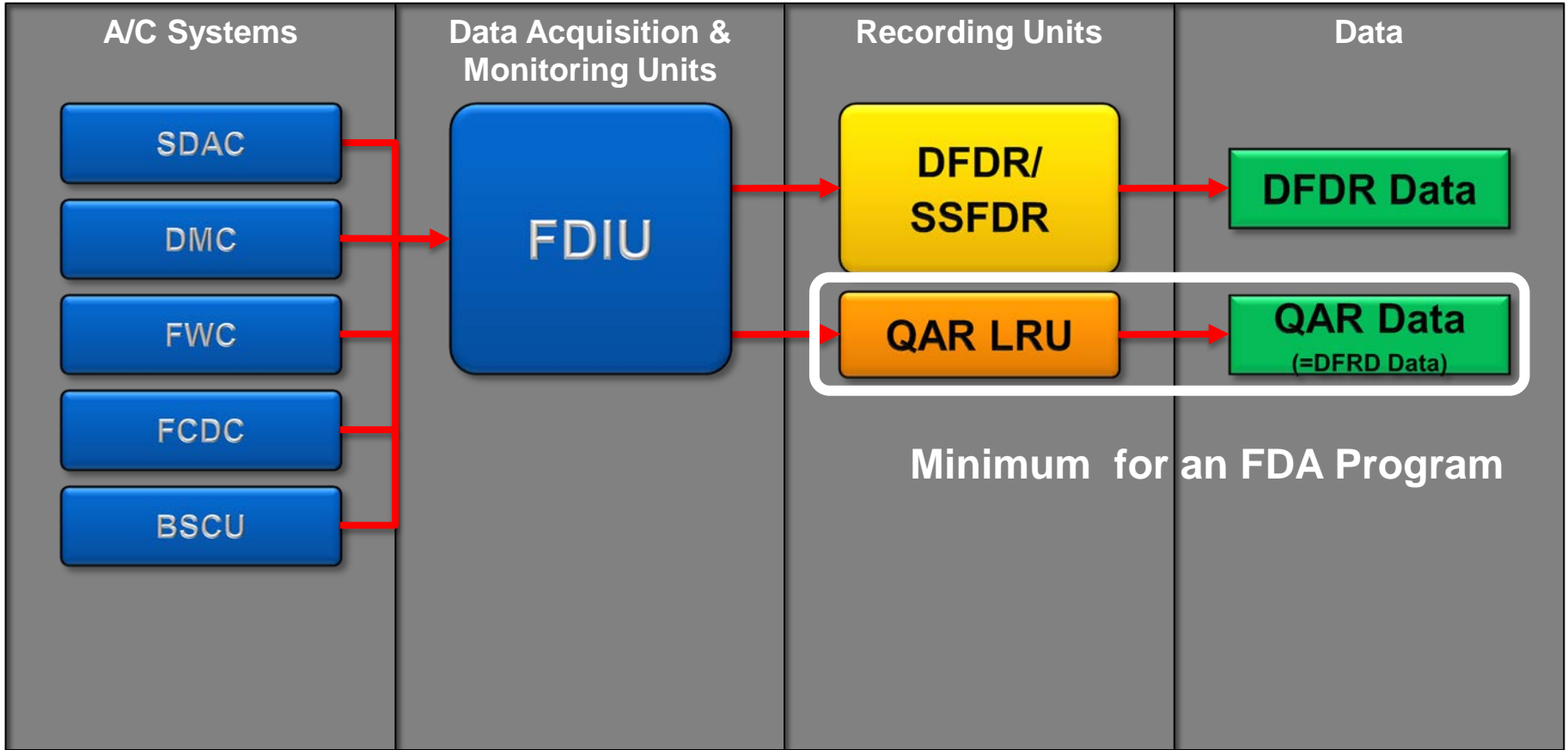
The **FDIU** (Flight Data Interface Unit) is in charge of picking parameters on the A/C ARINC network.



DFDR/SSFDR: Digital/Solid State Flight Data Recorder

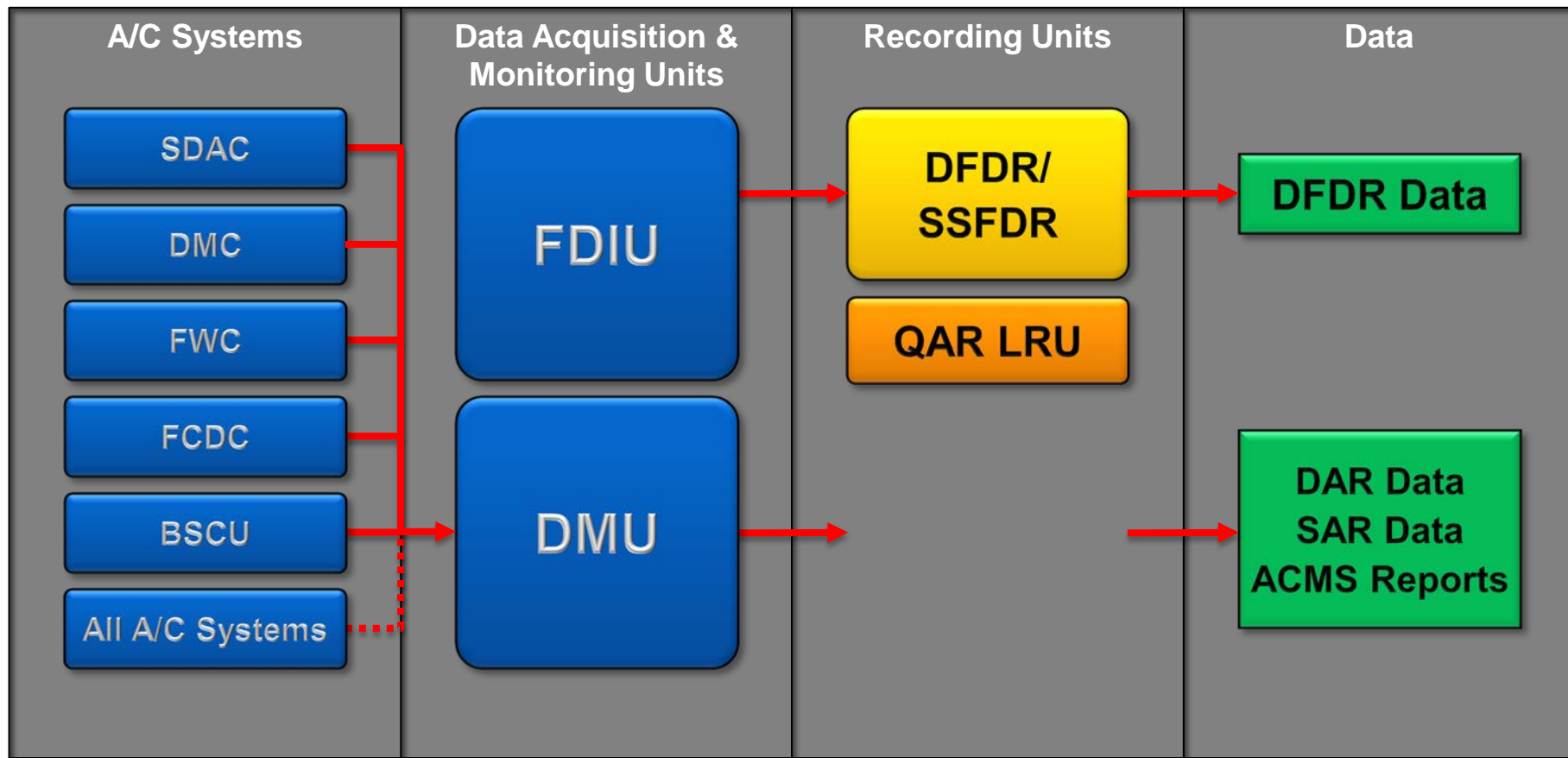
VARIOUS RECORDING CHAINS

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.



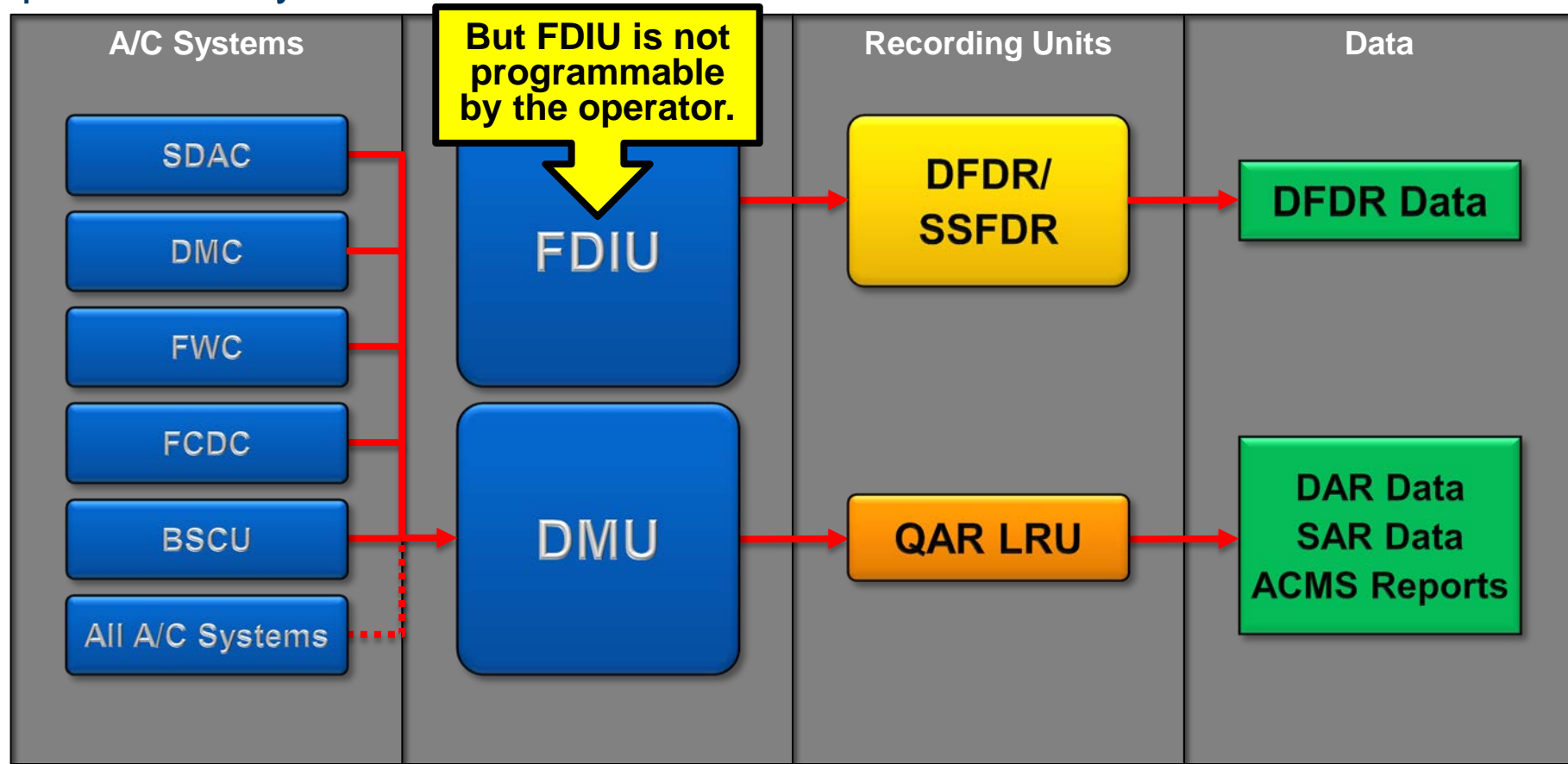
VARIOUS RECORDING CHAINS

DAR Data stands for **D**igital **A**CMS **R**ecorder **D**ata
DAR Data **and** **QAR** Data are used for FDA program.



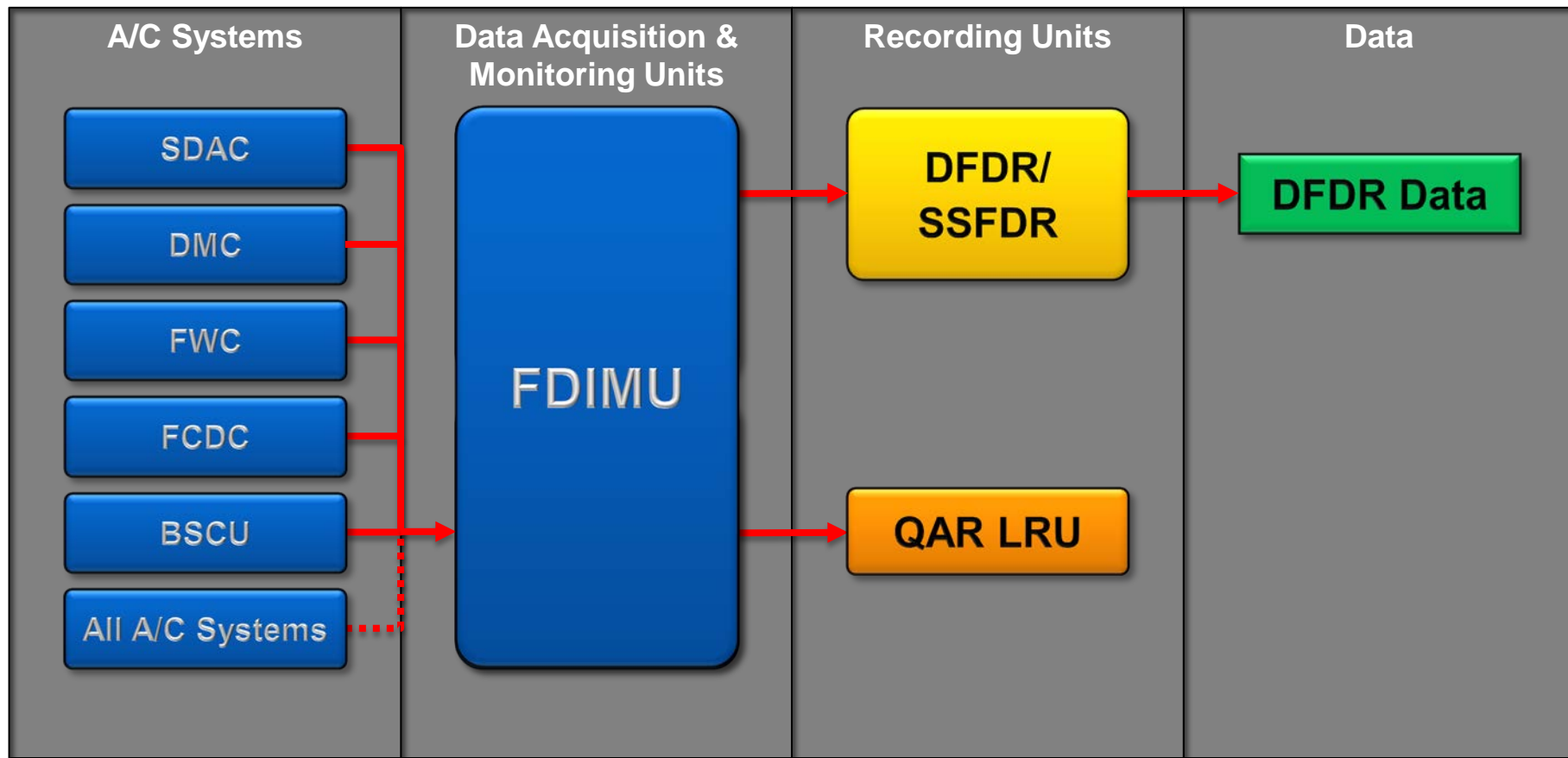
VARIOUS RECORDING CHAINS

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



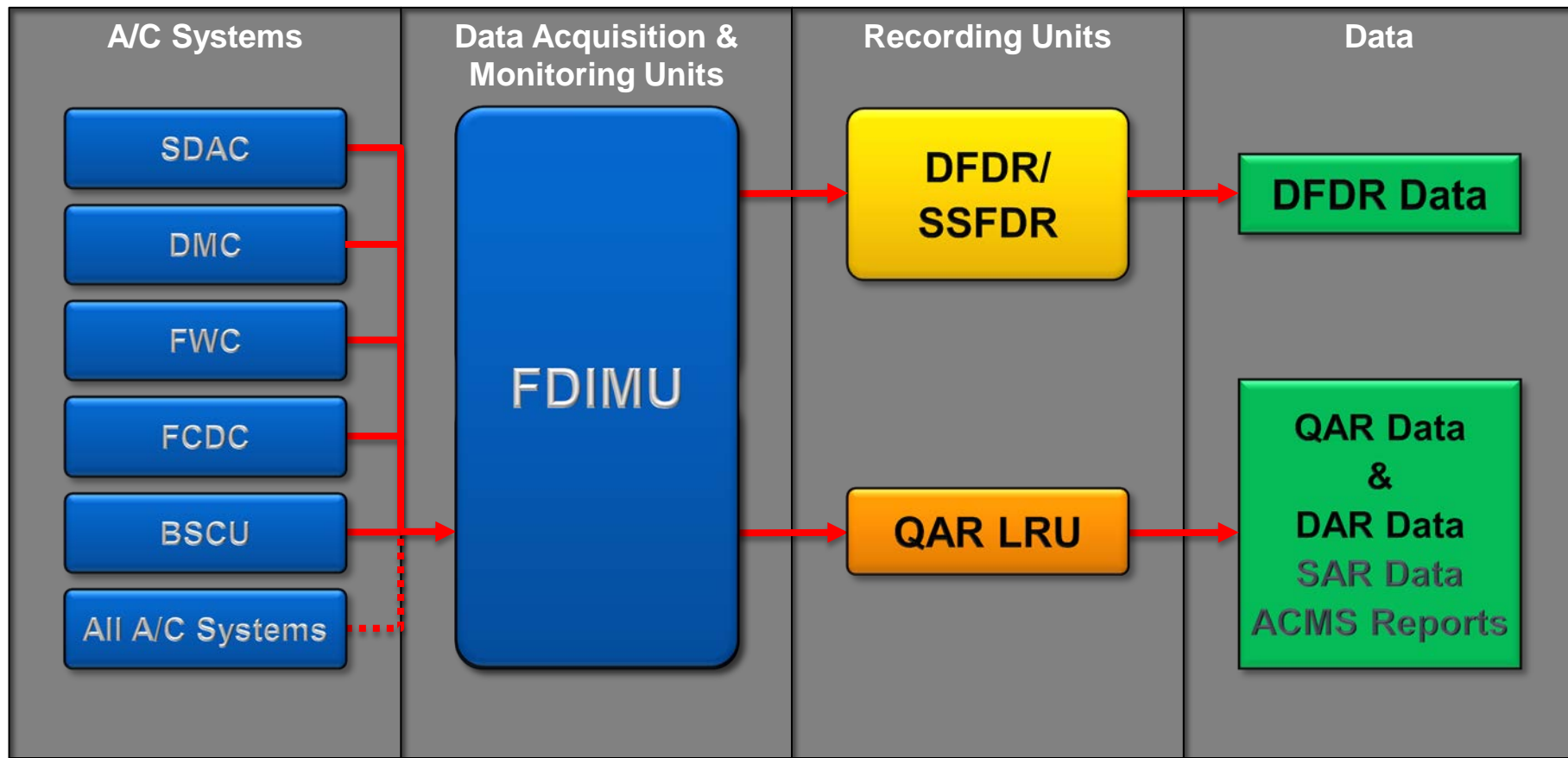
VARIOUS RECORDING CHAINS

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



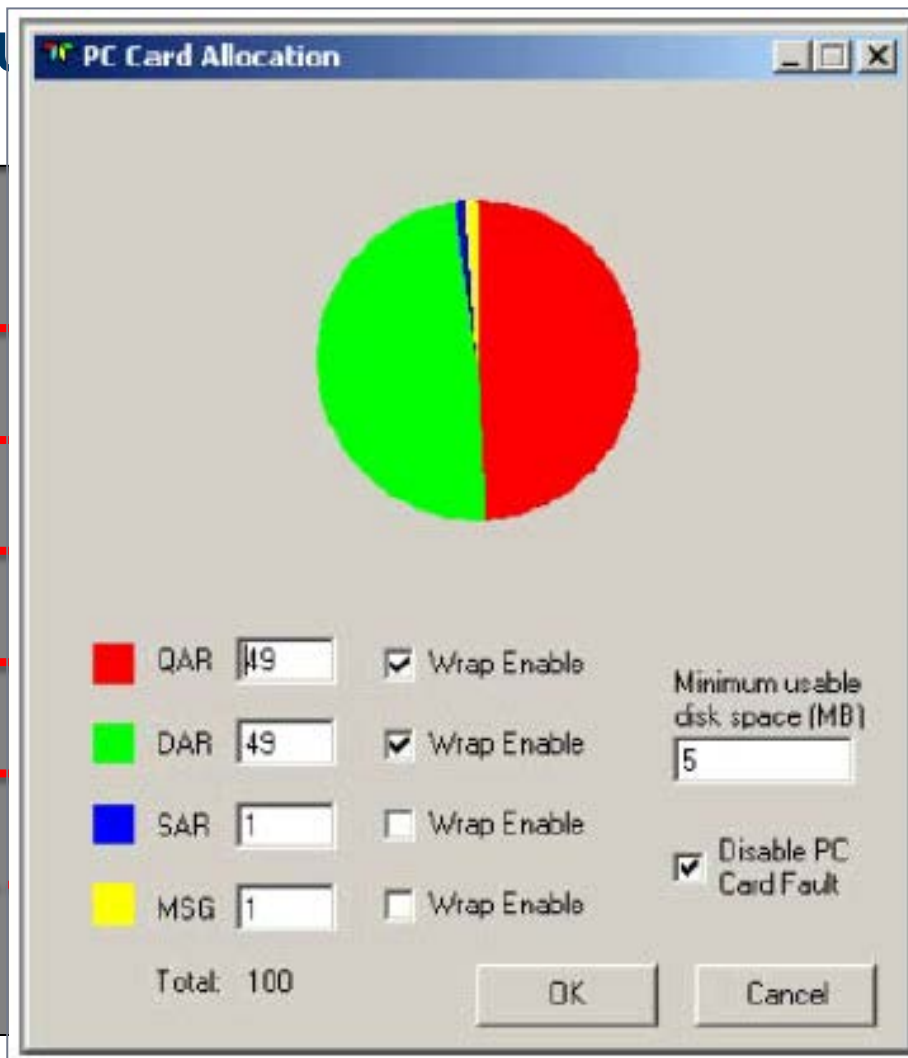
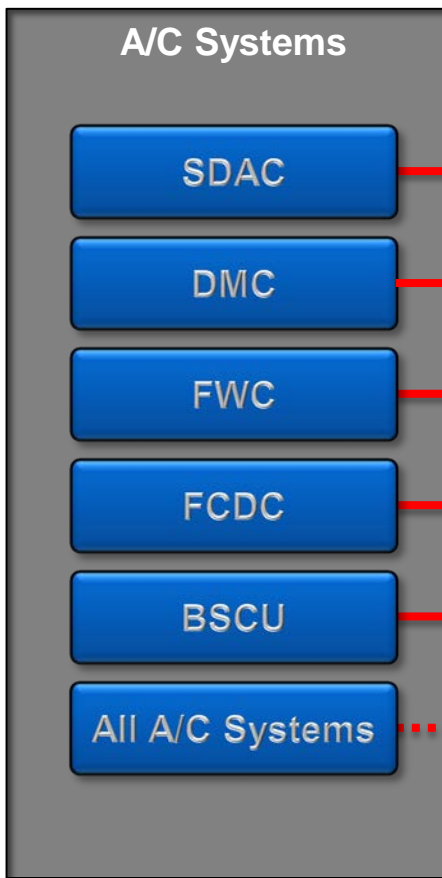
VARIOUS RECORDING CHAINS

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.

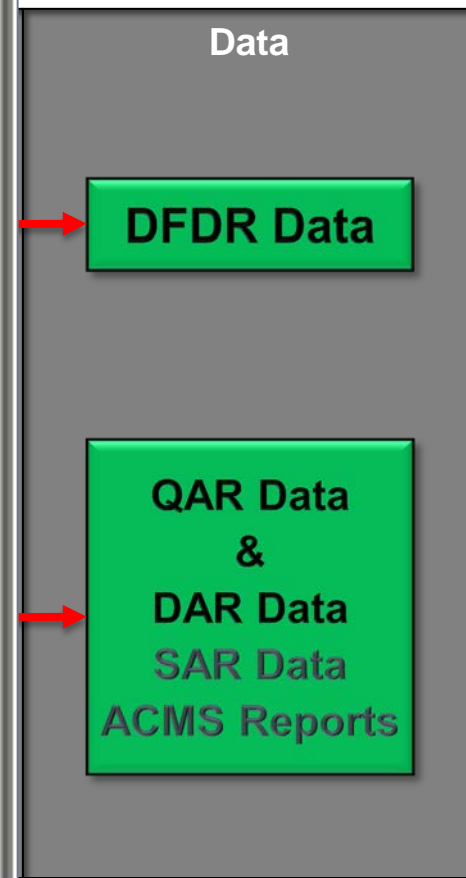


VARIOUS RECORDING CHAINS

FDIU and DMU
In that case **both**



oment: **FDIMU**
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

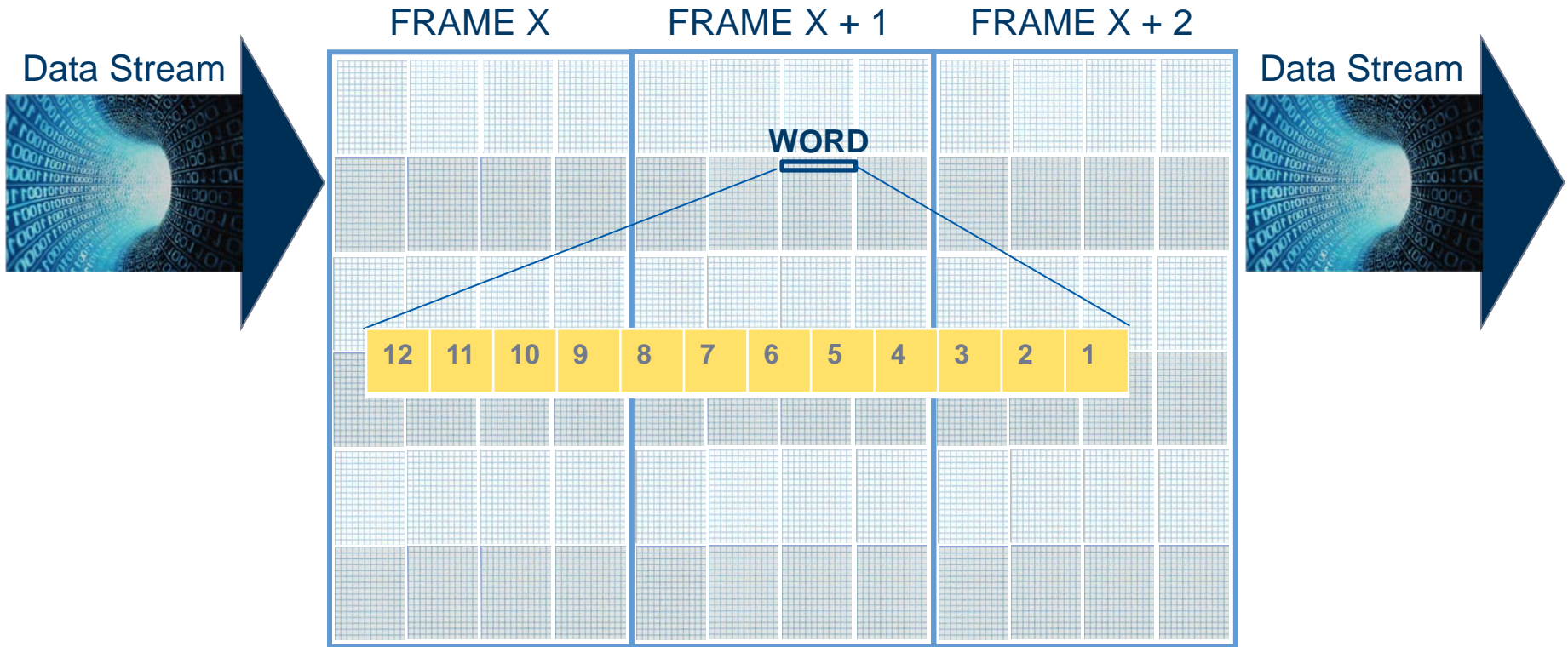
FRAME - SUBFRAME

PARAMETERS TO BE RECORDED

BEST PRACTICES

FRAME - SUBFRAME

WORDS are numbered from the beginning to the end of the SUBFRAME...

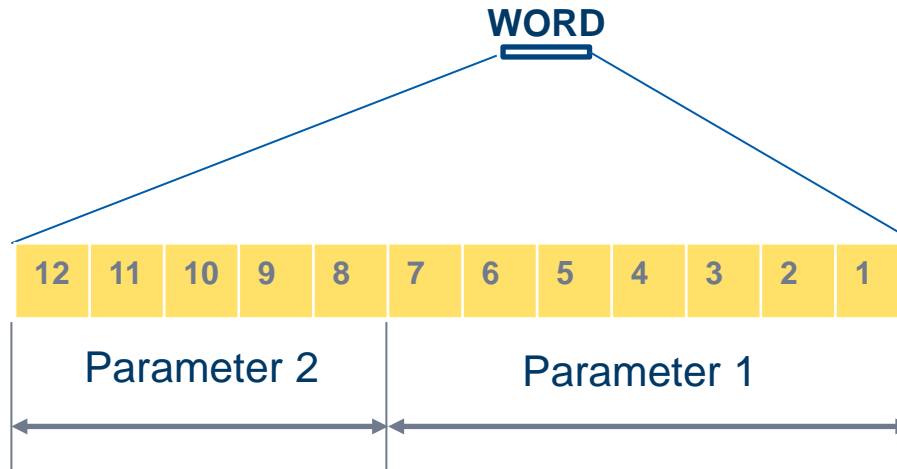


FRAME - SUBFRAME

Each word is made of 12 bits

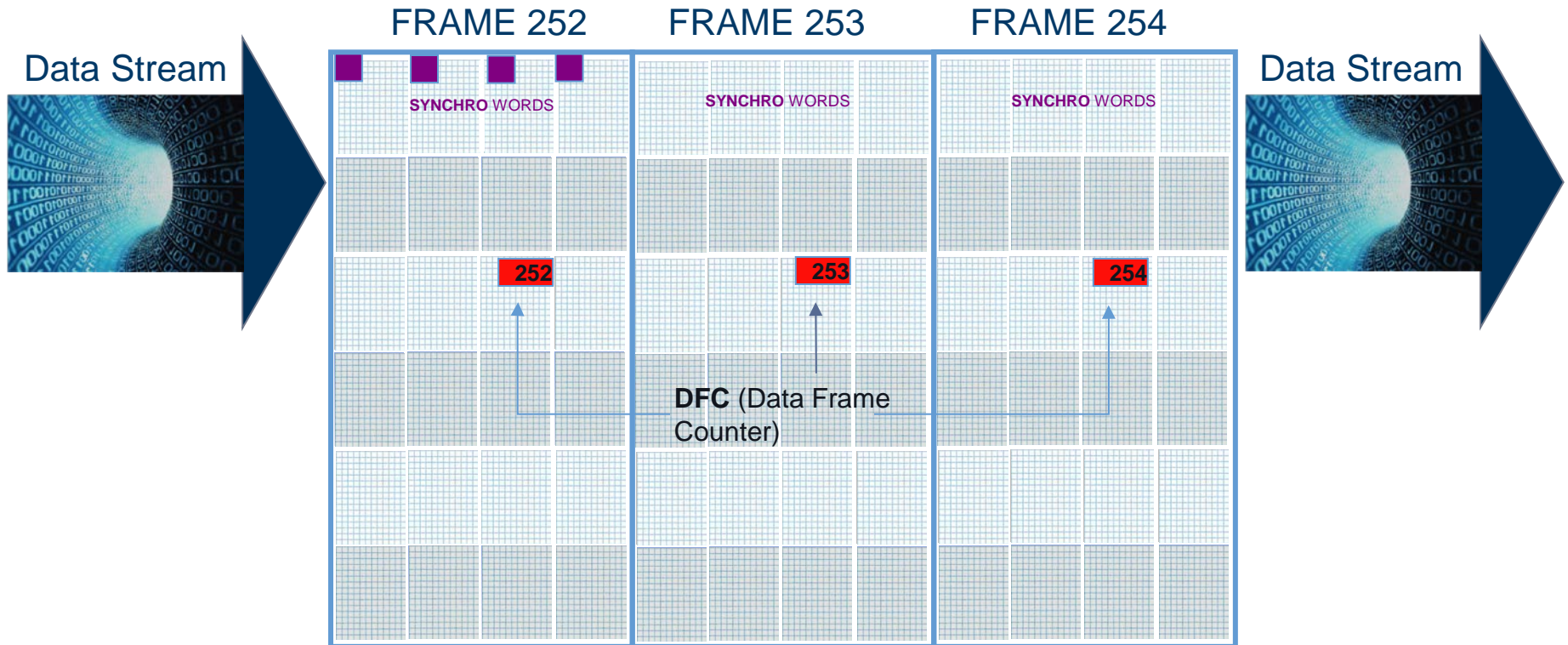
These bits contain the active parameter data

One word can contain several parameters



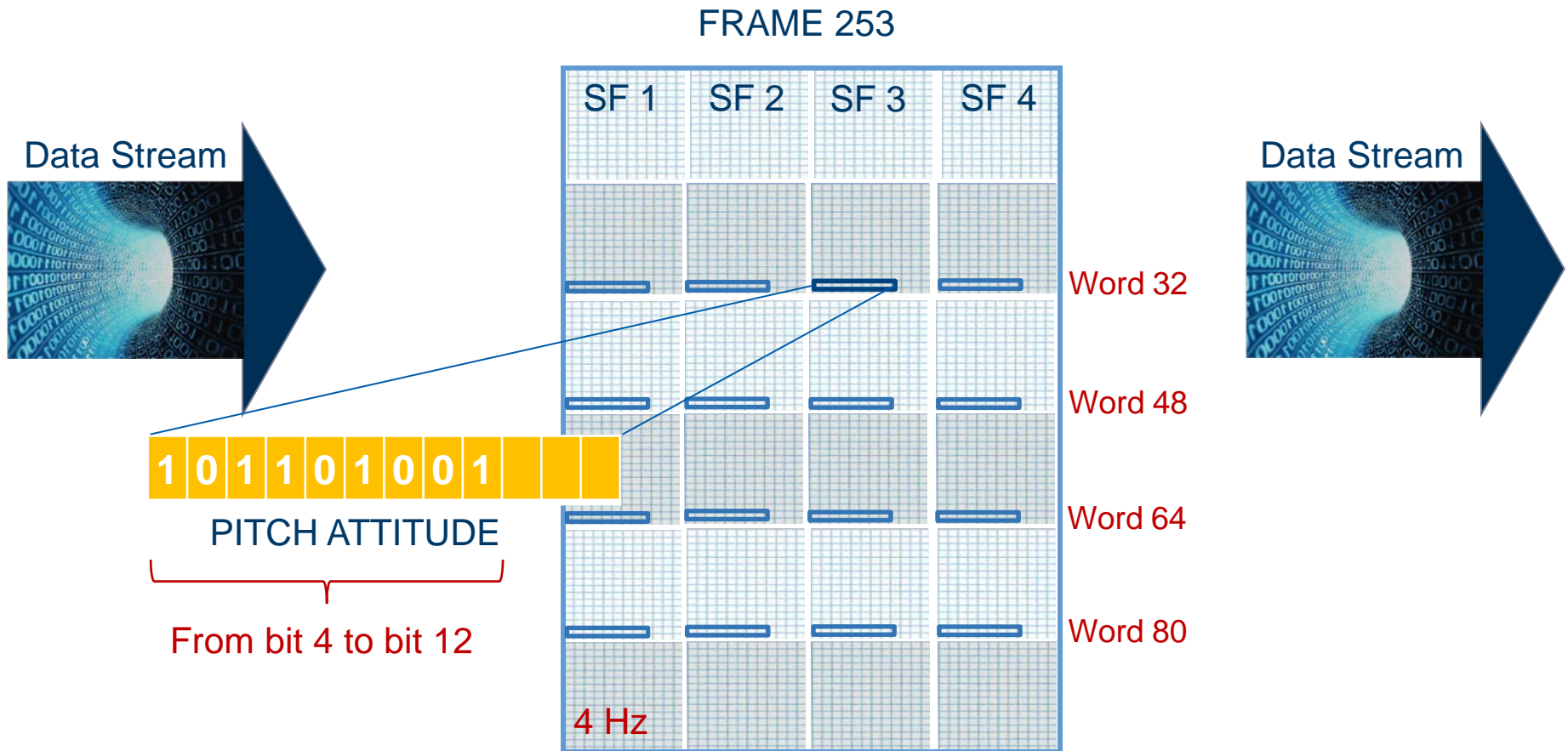
FRAME - SUBFRAME

The stream is managed by synchronisation words and a data frame counter which provide the continuous assessment capability on the stream.



FRAME - SUBFRAME

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 - SUBFRAME



FRAME 252

FRAME 253

FRAME 254



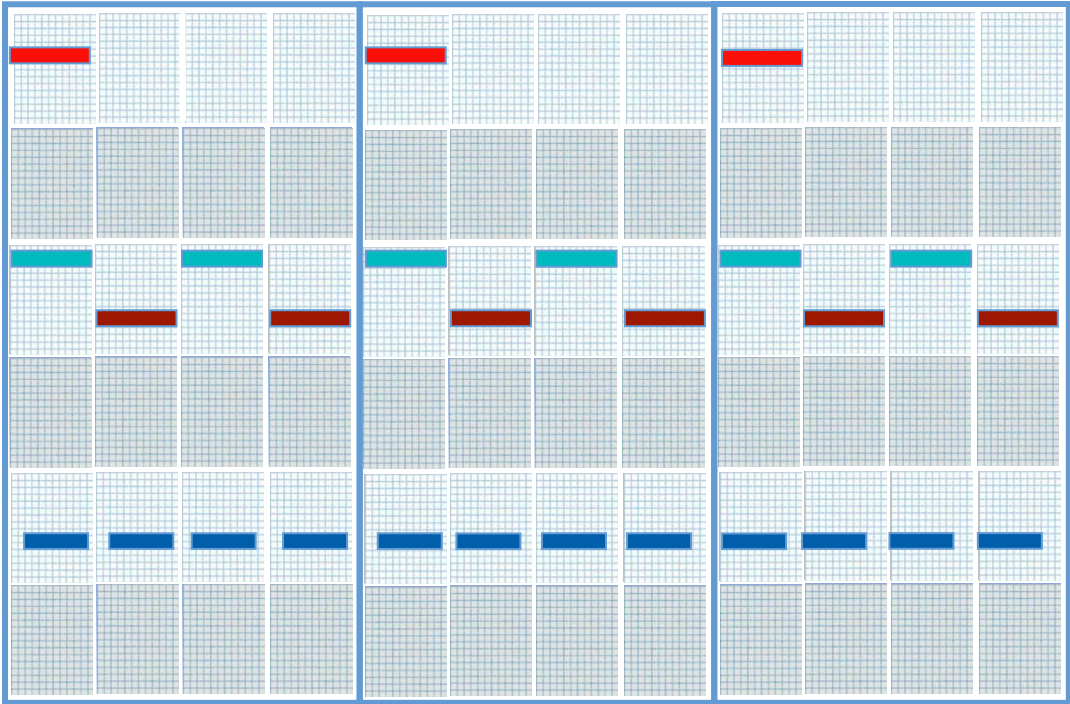
Data Stream

¼ Hz PARAMETER

½ Hz PARAMETER

½ Hz PARAMETER

1 Hz PARAMETER



FRAME - SUBFRAME



Data Stream



Data Stream

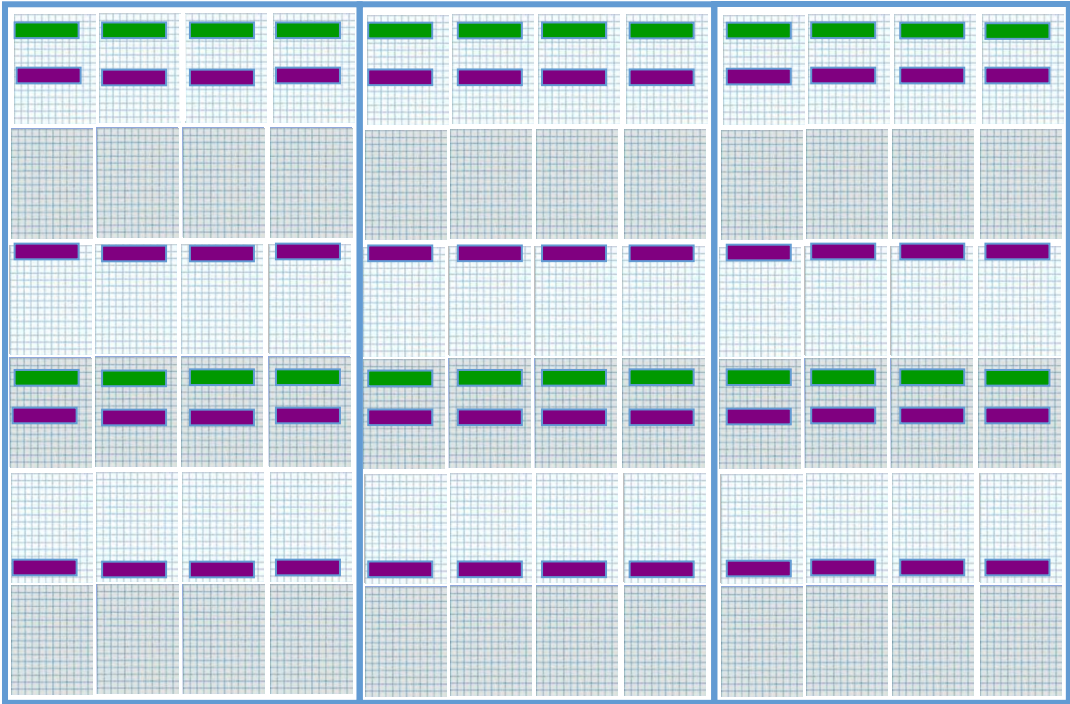
FRAME 252

FRAME 253

FRAME 254

2 Hz PARAMETER

4 Hz PARAMETER



RECORDING

HISTORY

VARIOUS RECORDING CHAINS

FRAME - SUBFRAME

PARAMETERS TO BE RECORDED

BEST PRACTICES

PARAMETER

Regulations on p
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These regulation
1. ICAO - Anne

Table A8-1. Parameter Guidance for Crash Protected Flight Data Recorders

Serial number	Parameter	Measurement range	Maximum sampling and recording interval (seconds)	Accuracy limits (sensor input compared to FDR read-out)	Recording resolution
1	Time (UTC when available, otherwise relative time count or GPS time sync)	24 hours	4	±0.125% per hour	1 second
2	Pressure-altitude	-300 m (-1 000 ft) to maximum certificated altitude of aircraft +1 500 m (+5 000 ft)	1	±30 m to ±200 m (±100 ft to ±700 ft)	1.5 m (5 ft)
3	Indicated airspeed or calibrated airspeed	95 km/h (50 kt) to max V_{SO} (Note 1) V_{SO} to 1.2 V_{D} (Note 2)	1	±5% ±3%	1 kt (0.5 kt recommended)
4	Heading (primary flight crew reference)	360°	1	±2°	0.5°
5	Normal acceleration (Note 3)	-3 g to +6 g	0.125	±1% of maximum range excluding datum error of ±0.05 g	0.004 g
6	Pitch attitude	±75° or usable range whichever is greater	0.25	±2°	0.5°
7	Roll attitude	±180°	0.25	±2°	0.5°
8	Radio transmission keying	On-off (one discrete)	1		
9	Power on each engine (Note 4)	Full range	1 (per engine)	±2%	0.2% of full range or the resolution required to operate the aircraft
10*	Trailing edge flap and cockpit control selection	Full range or each discrete position	2	±5% or as pilot's indicator	0.5% of full range or the resolution required to operate the aircraft
11*	Leading edge flap and cockpit control selection	Full range or each discrete position	2	±5% or as pilot's indicator	0.5% of full range or the resolution required to operate the aircraft
12*	Thrust reverser position	Stowed, in transit, and reverse	1 (per engine)		
13*	Ground spoiler/speed brake selection (selection and position)	Full range or each discrete position	1	±2% unless higher accuracy uniquely required	0.2% of full range
14	Outside air temperature	Sensor range	2	±2°C	0.3°C
15*	Autopilot/auto throttle/AFCS mode and engagement status	A suitable combination of discrettes	1		
16	Longitudinal acceleration (Note 3)	±1 g	0.25	±0.015 g excluding a datum error of ±0.05 g	0.004 g
<i>Note.— The preceding 16 parameters satisfy the requirements for a Type II FDR.</i>					
17	Lateral acceleration (Note 3)	±1 g	0.25	±0.015 g excluding a datum error of ±0.05 g	0.004 g

DFDR

5.3 - Appendix 8

PARAMETERS TO BE RECORDED

Regulation
They also
These re
1. ICAC
2. EAS

Table 1: FDR

No	Parameter	Range	Sampling interval in seconds	Accuracy limits (sensor input compared to FDR readout)	Recommended resolution in readout	Remarks
1a	Time	24 hours	4	± 0.125 % per hour	1 second	(a) UTC time preferred where available.
<p>AMC2 CAT.IDE.A.190 Flight data recorder</p> <p>OPERATIONAL PERFORMANCE REQUIREMENTS FOR AEROPLANES FIRST ISSUED WITH AN INDIVIDUAL COFA ON OR AFTER 1 APRIL 1998 AND BEFORE 1 JANUARY 2016</p> <p>(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.</p>						
5	Normal acceleration	-3 g to +6 g	0.125	1 % of maximum range excluding a datum error of 5 %	0.004 g	The recording resolution may be rounded from 0.004 g to 0.01 g provided that one sample is recorded at full resolution at least every 4 seconds.
6	Pitch attitude	±75 degrees	0.25	±2 degrees	0.5 degrees	
7	Roll attitude	±180 degrees	0.5	±2 degrees	0.5 degrees	
8	Manual radio transmission keying	Discrete	1	-	-	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.
9a	Propulsive thrust / power on each engine	Full range	Each engine each second	±2 %	0.2 % of full range	Sufficient parameters e.g. EPR/N, or Torque/NP 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.
9b	Flight crew compartment thrust / power lever position	Full range	Each lever each second	±2 % or sufficient to determine any gated position	2 % of full range	Parameter 9b must be recorded for aeroplanes with non-mechanically linked cockpit-engine controls, otherwise recommended.

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

AMC3 CAT.IDE.A.190 Flight data recorder

AIR OPS and AMC/GM - May 2013
Amendment Part-OUT

359 | CAT

AIR OPS CAT.IDE.A

ndix 8

PARAMETERS TO BE RECORDED

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

N°	Parameter	Minimum Recording Range (refer to para II-A.7)	Maximum recording interval in seconds (refer to para II-A.8)	Recording Accuracy (refer to para II-A.9)	Recording Resolution (refer to para II-A.11)	Remarks
1a or 1b 1c	Time Relative Time Count GPS Time Sync	24 hours 0 to 4095 Discrete	4 4 4	$\pm 0.125\%$ per hour $\pm 0.125\%$ per hour	1 second	(a) UTC time preferred where available. (b) Counter increments each 4 seconds of system operation. (c) To establish whether the aircraft clocks are synchronised to GPS time
2	Pressure Altitude	- 1 000 ft to maximum certified altitude of aircraft + 5 000 ft	1	± 100 ft to ± 700 ft Refer to Table II-A.3	5 ft	Refer to paragraph II-A.6.1
3	Indicated Airspeed or Calibrated Airspeed	50 kt or minimum value from installed pitot static system to Max V_{S0} Max V_{S0} to $1.2 V_D$	1	$\pm 5\%$ $\pm 3\%$	1 kt (0.5 kt recommended)	Refer to paragraph II-A.6.1
4	Heading (Primary flight crew reference)	0 - 360 degrees and discrete 'true' or 'mag'	1	± 2 degrees	0.5 degrees	When true or magnetic heading can be selected, the primary heading reference, a discrete indicating selection shall be recorded.
5	Normal Acceleration	- 3 g to + 6 g	0.125	± 0.09 g excluding a datum error of ± 0.45 g	0.004 g	
6	Pitch Attitude	± 90 degrees	0.25	± 2 degrees	0.5 degree	Accuracy will be apply only within $\pm 75^\circ$ range
7	Roll Attitude	± 180 degrees	0.5	± 2 degrees	0.5 degree	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.
8	Manual Radio Transmission Keying and CVR/FDR synchronization reference	Discrete(s)	1	-	-	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)

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 - Aeroplanes - Chapter 6 Para 6.3 - Appendix 8
2. EASA - AIR OPERATIONS - 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

PARAMETERS TO BE RECORDED

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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)

PARAMETERS TO BE RECORDED

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.

DFDR DATA
FRAME



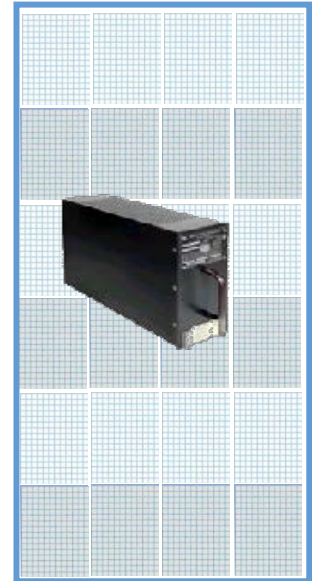
PARAMETERS TO BE RECORDED

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.

DAR DATA
FRAME



RECORDING

HISTORY

VARIOUS RECORDING CHAINS

FRAME - SUBFRAME

PARAMETERS TO BE RECORDED

BEST PRACTICES

RECORDING - BEST PRACTICES



RECORDING - 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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