FDA Seminar – Miami
25-27 October 2016

FDA Limits

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FDA Limits - Content

1. How Data is recorded?
2. Which parameters to record?
3. What does recorded Data look like?
4. How to make it readable in an FDA software?

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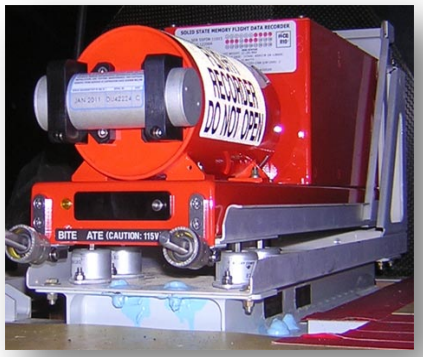
FDA Limits – How Data is recorded ?



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).

FDA Limits – How Data is recorded ?

Sensor

Analogic-
Numeric
Converter

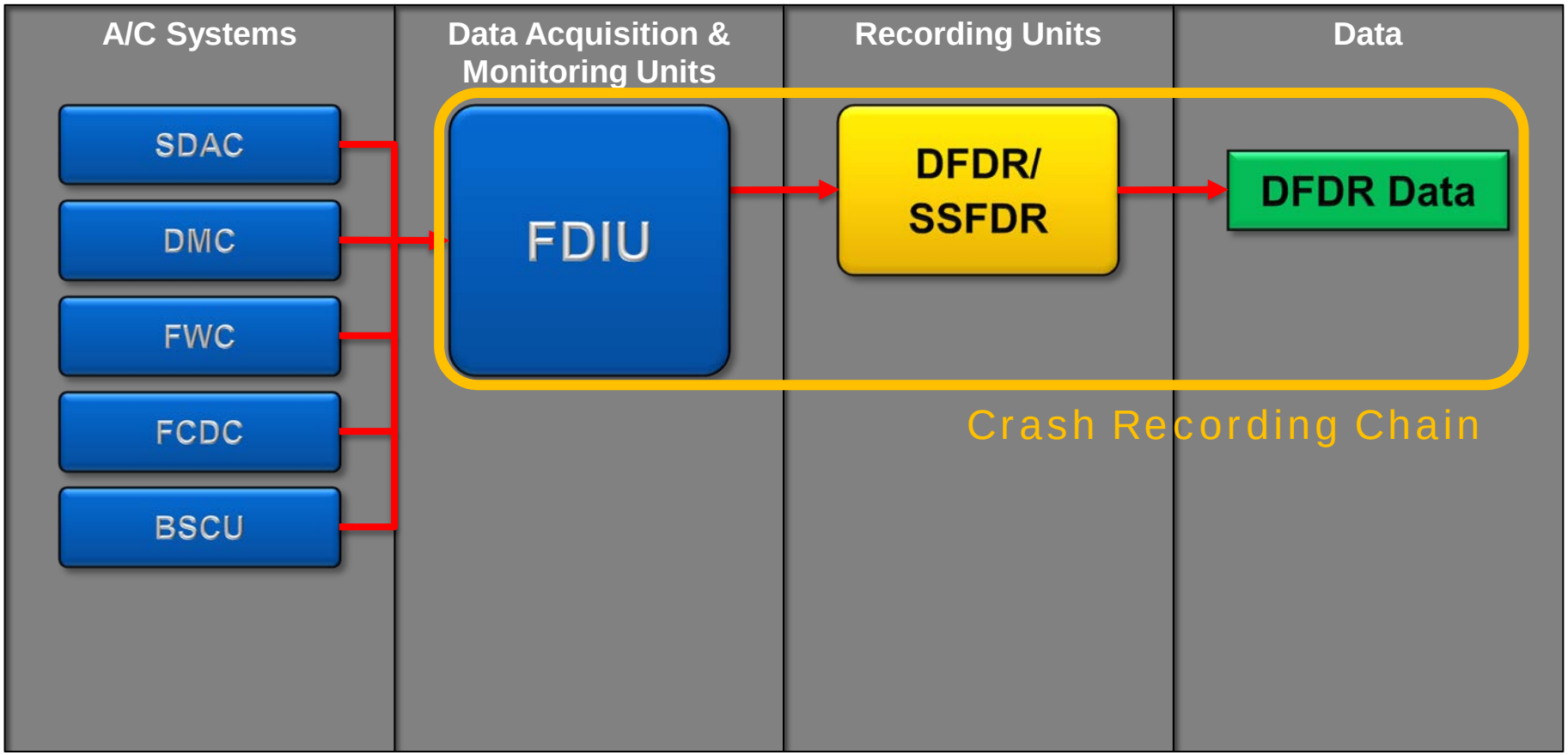
A/C
Computer

A/C Systems

FDIU/DMU
FDIMU

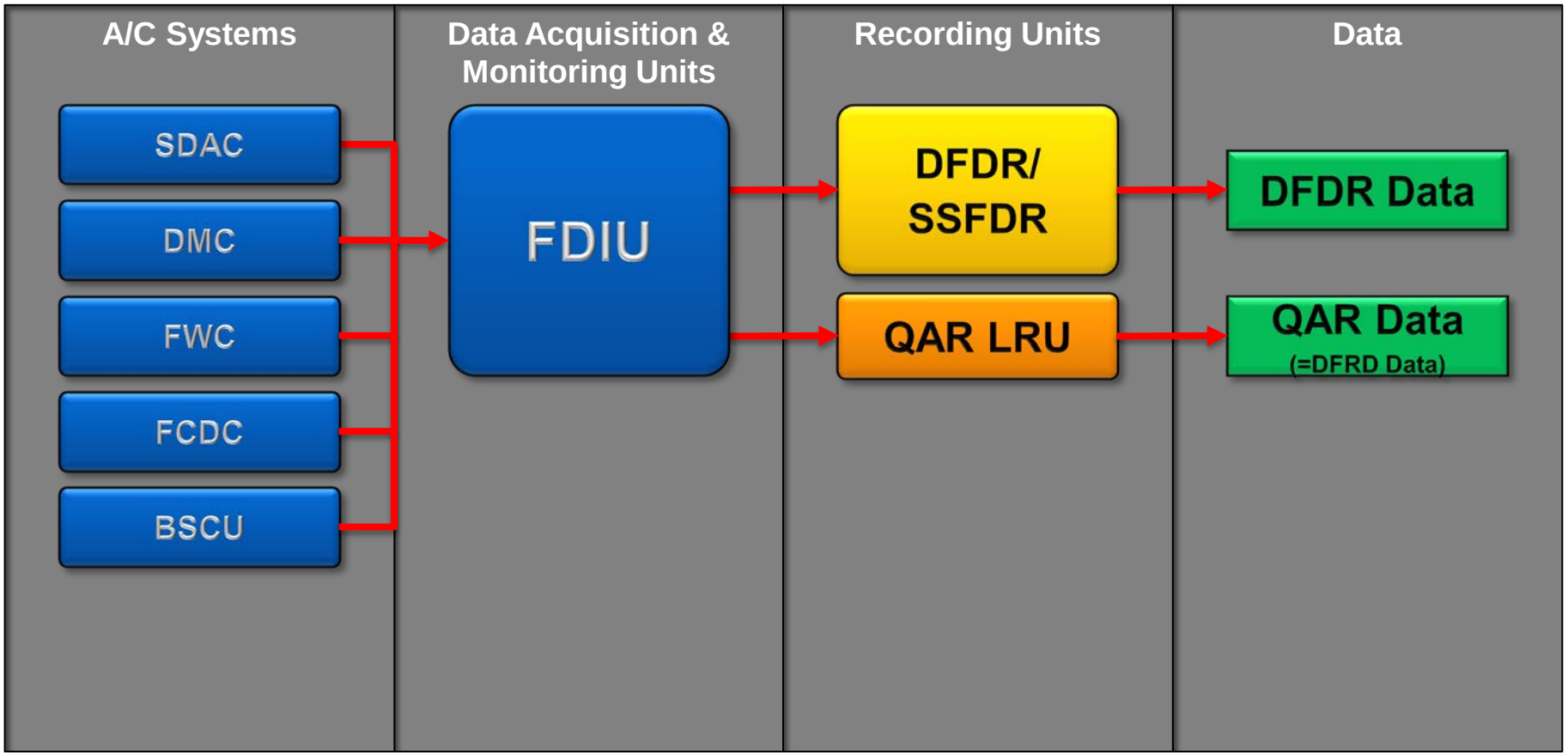
FDA Limits – How Data is recorded ?

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



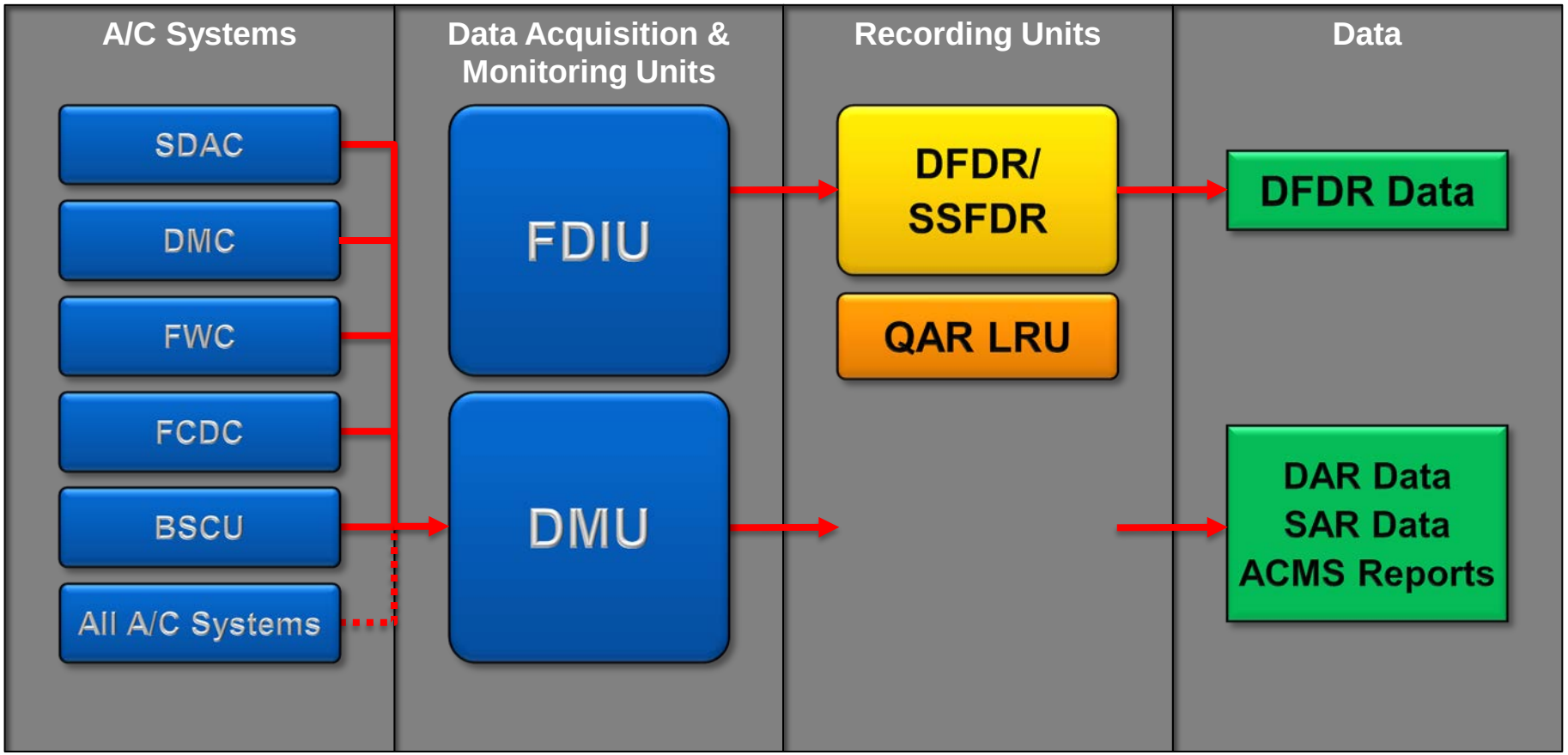
FDA Limits – How Data is recorded ?

The FDIU provides the same Data to the DFDR and to a QAR LRU.



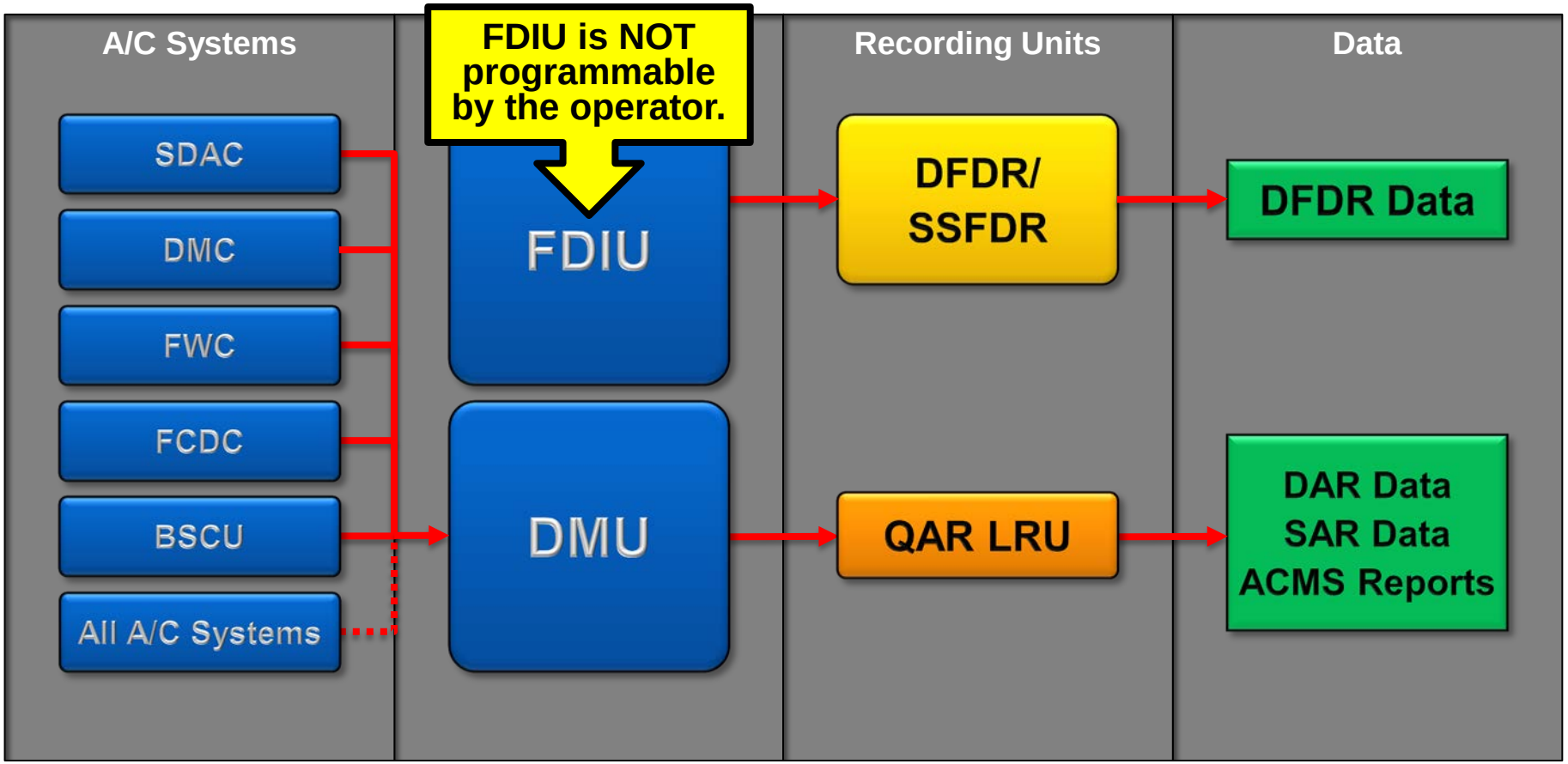
FDA Limits – How Data is recorded ?

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



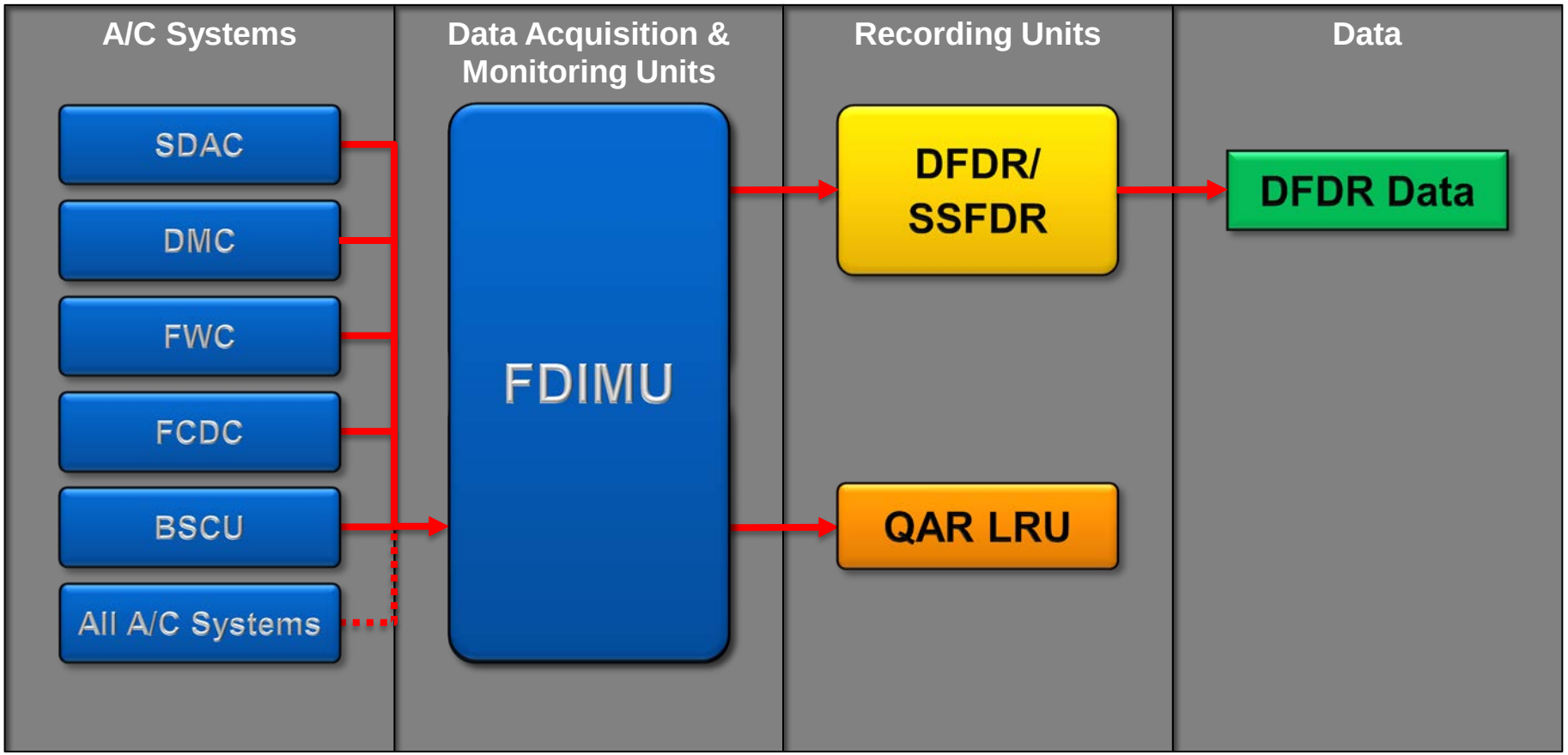
FDA Limits – How Data is recorded ?

DMU can be programmed by an operator to record any convenient parameters provided available on the ARINC network.



FDA Limits – How Data is recorded ?

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



FDA Limits – How Data is recorded ?

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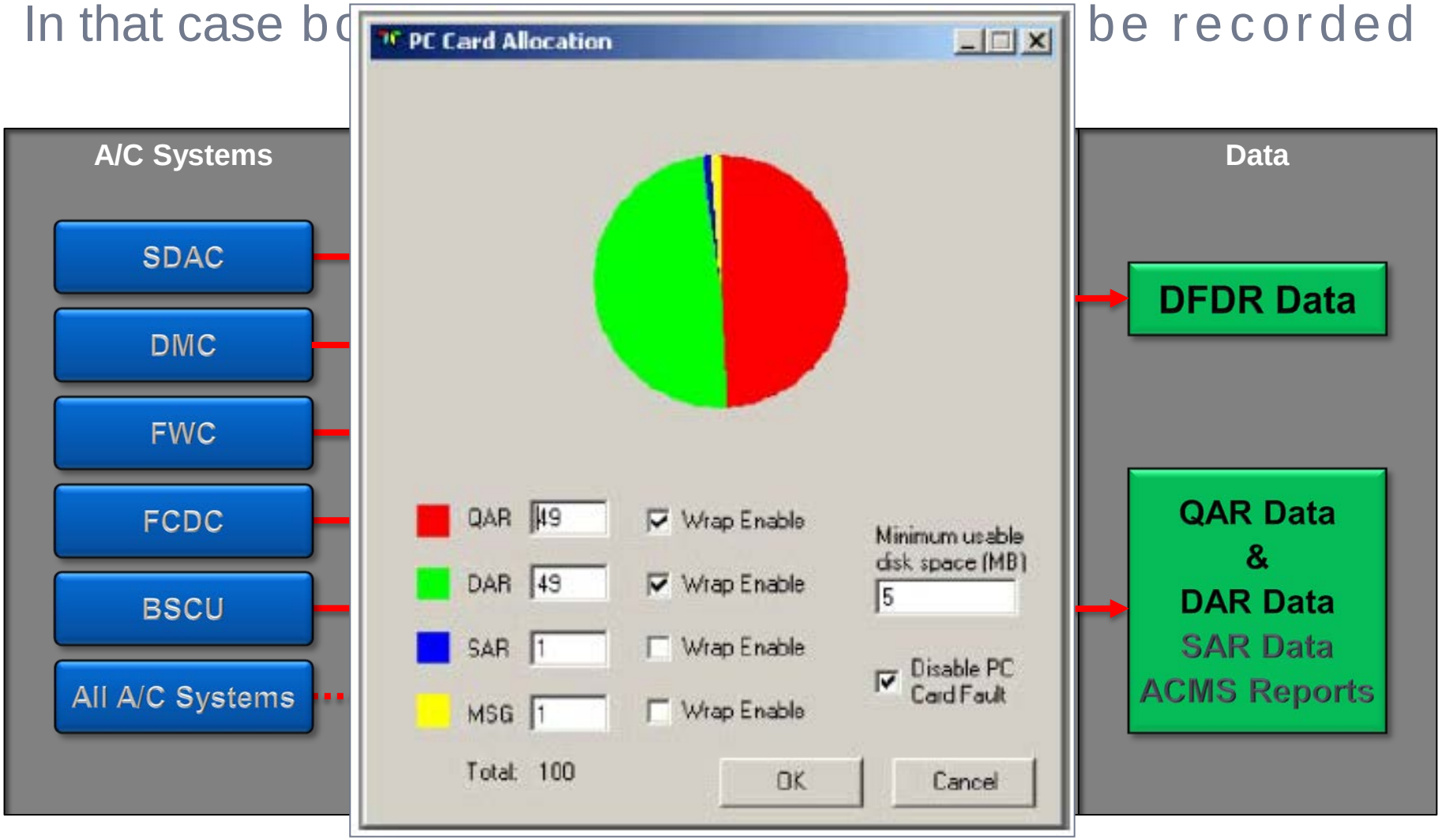

FDA Limits – How Data is recorded ?

Different Recording Systems

- Different Data Files
- Different decoding programs

Different Parameter Sources

- Different raw parameter gross values

Homogeneity Issue

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FDA Limits - Content

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FDA Limits –

Regulatio … the DFDR

- ICAO - …

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 ±5%	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 discretes	1		
16	Longitudinal acceleration *(Note 3)*	±1 g	0.25	±0.015 g excluding a datum error of ±0.05 g	0.004 g
Note.— The preceding 16 parameters satisfy the requirements for a Type II FDR.					
17	Lateral acceleration *(Note 3)*	±1 g	0.25	±0.015 g excluding a datum error of ±0.05 g	0.004 g

FDA Limits – Which parameters to record ?

Regulations on paramaters only concern the DFDR

- IC
- E
  A

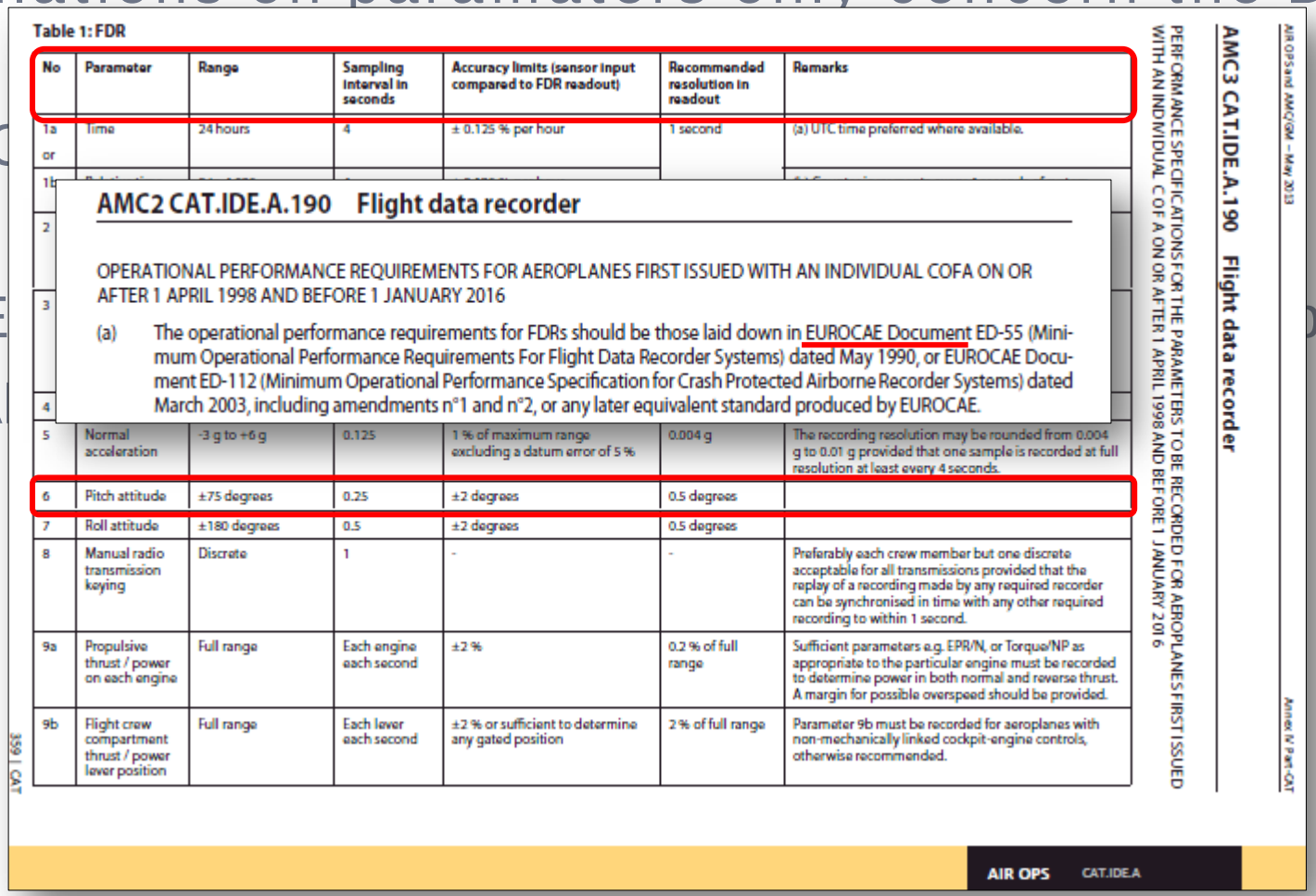

Table 1: FDR

No	Parameter	Range	Sampling interval in seconds	Accuracy limits (sensor input compared to FDR readout)	Recommended resolution in readout	Remarks
1a or	Time	24 hours	4	± 0.125 % per hour	1 second	(a) UTC time preferred where available.
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.

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.

AMC3 CAT.IDE.A.190 Flight data recorder

PERFORMANCE SPECIFICATIONS FOR THE PARAMETERS TO BE RECORDED FOR AEROPLANES FIRST ISSUED WITH AN INDIVIDUAL C OF A ON OR AFTER 1 APRIL 1998 AND BEFORE 1 JANUARY 2016

AIR OPS and AMC/GM – May 2013 Annex IV Part-CAT

AIR OPS CAT.IDE.A

FDA Limits – Which parameters to record ?

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	± 0.125% per hour ± 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 certificated 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	± 5% ± 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 ± 75° 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)

FDA Limits – Which parameters to record ?

Regulations on paramaters only concern the DFDR

- ICAO - Annex 6 Part I – Aereoplanes
  Chapter 6 Para 6.3 - Appendix 8
- EASA - AIR OPERATIONS - Commercial Air Transport
  AMC CAT.IDE.A.190 Flight Data Recorder
- EUROCAE - ED-55 / ED-112 / ED-112 A
  MOPS for Crash Protected Airborne Recorder Systems
- FAR 121.334 Digital Flight Data Recorders

Appendix M to Part 121 - Airplane Flight Recorder Specifications

FDA Limits – Which parameters to record ?

Airbus adds to these lists, parameters also required by Airbus Flight Safety and Airbus Handling Quality.

All these parameters 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 identified by a D.

D09 = Vertical Speed

FDA Limits – Which parameters to record ?

For the DAR Data Frame there is no regulatory requirement but most of the previous parameters (Mandatory and Documentary) are recorded.

Standard DAR Data Frames exist but they are fully customizable by the operator.

These modifications will obviously affect the final picture of a flight into an FDA software.

FDA Limits – Which parameters to record ?

More than 100 standards exist (QAR & DAR)

Homogeneity Issue

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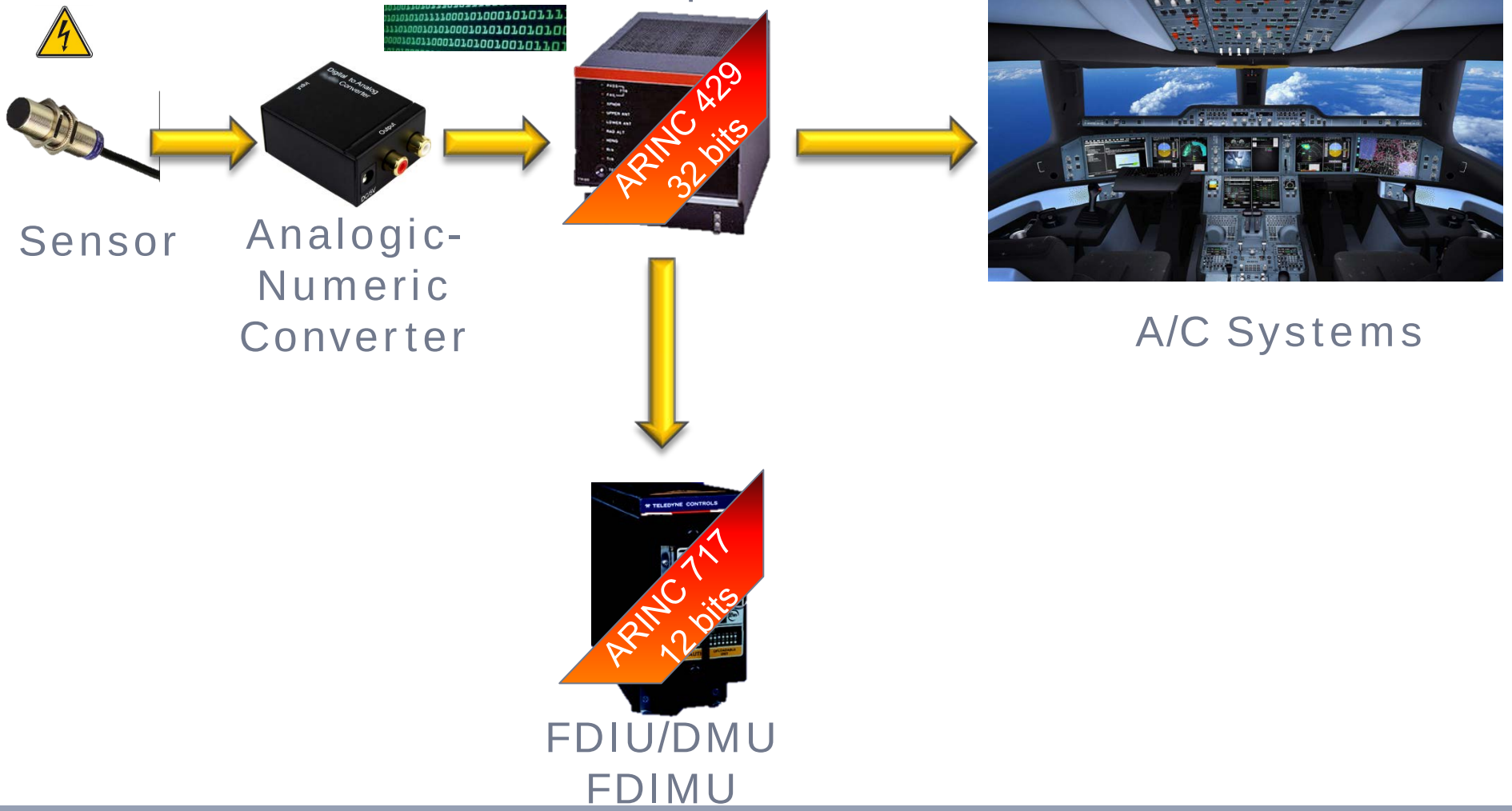
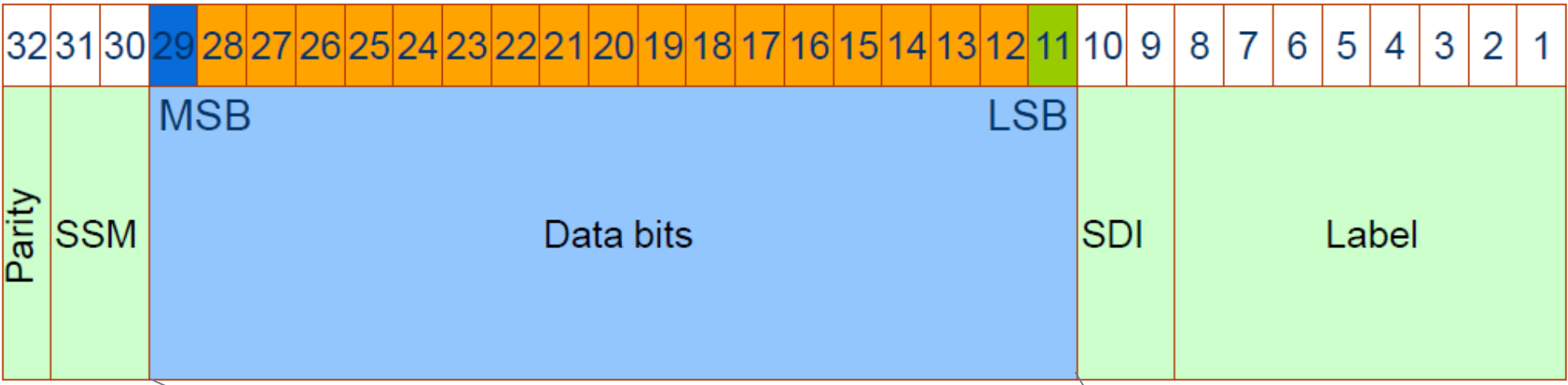
FDA Limits – What does recorded Data look like ?

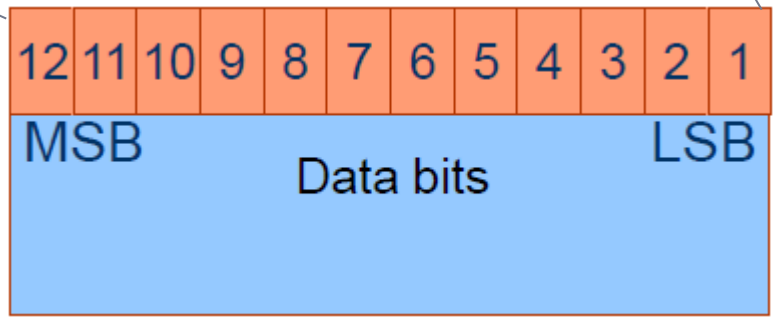


FDA Limits – What does recorded Data look like ?

ARINC 429

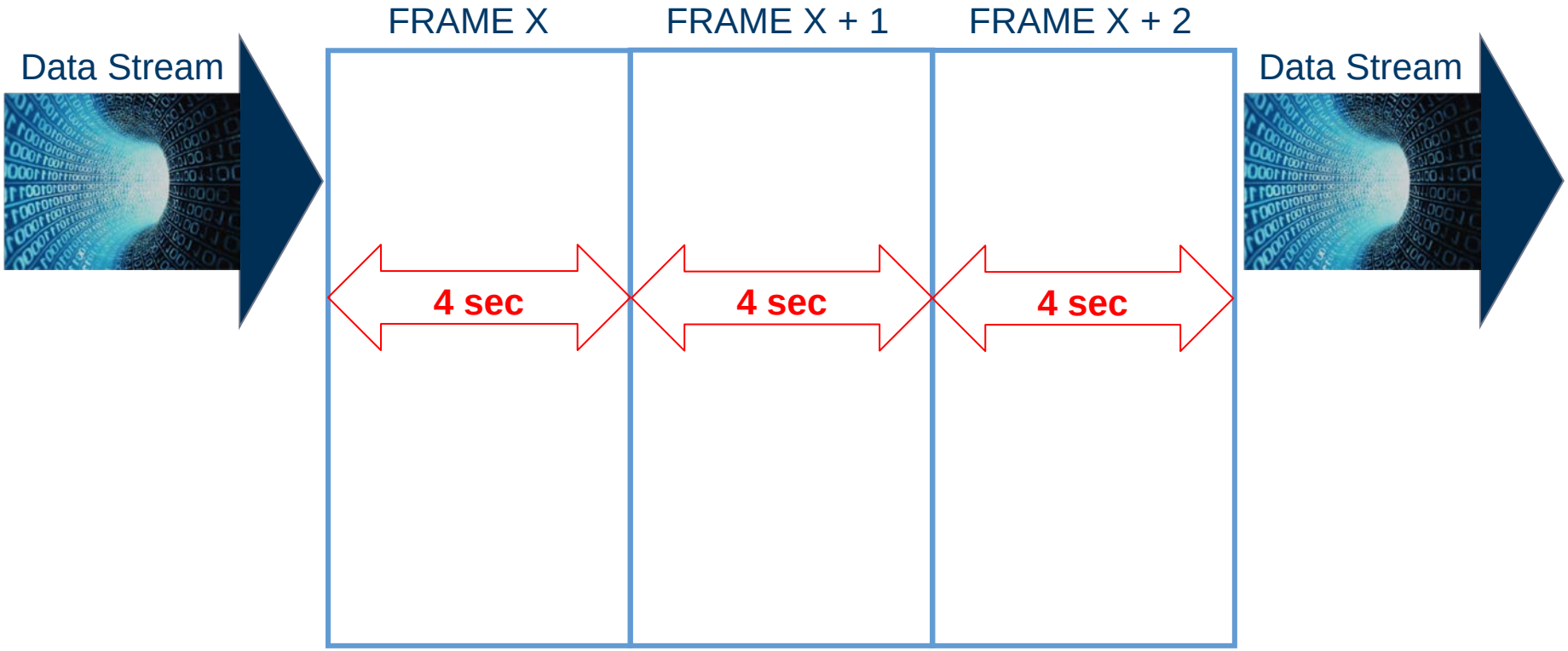


ARINC 717



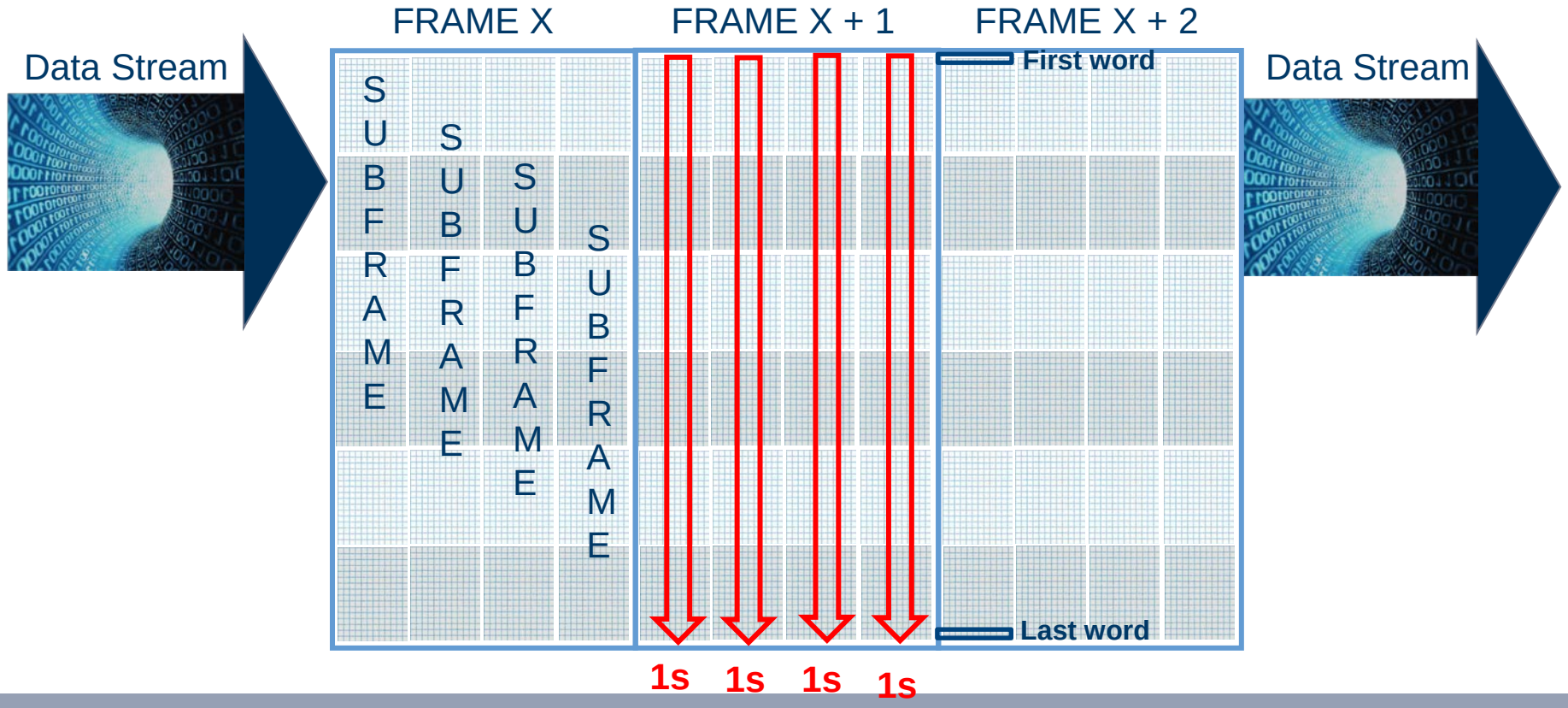
FDA Limits – What does recorded Data look like ?

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



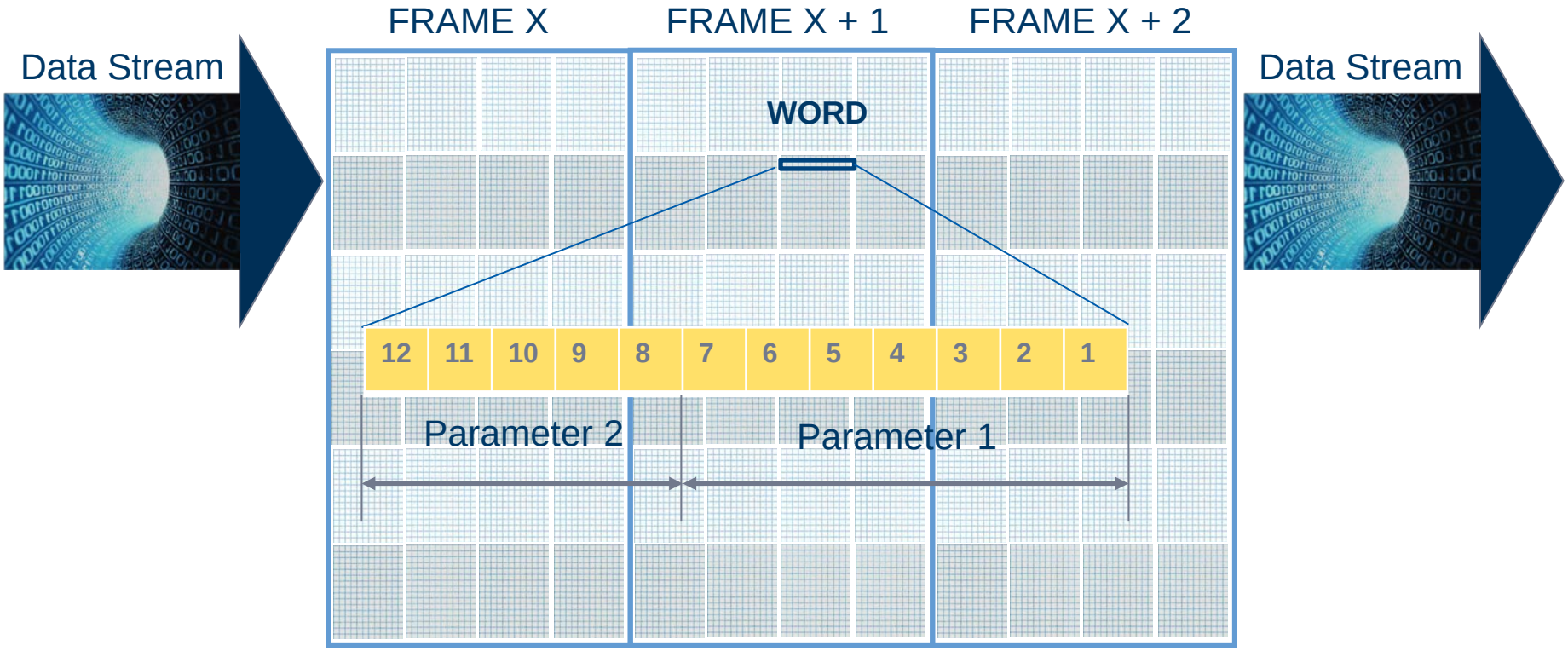
FDA Limits – What does recorded Data look like ?

Each Frame is divided into 4 Subframes
Each subframe lasts 1 second and contains a number of words
Words are numbered from the beginning to the end of the SF



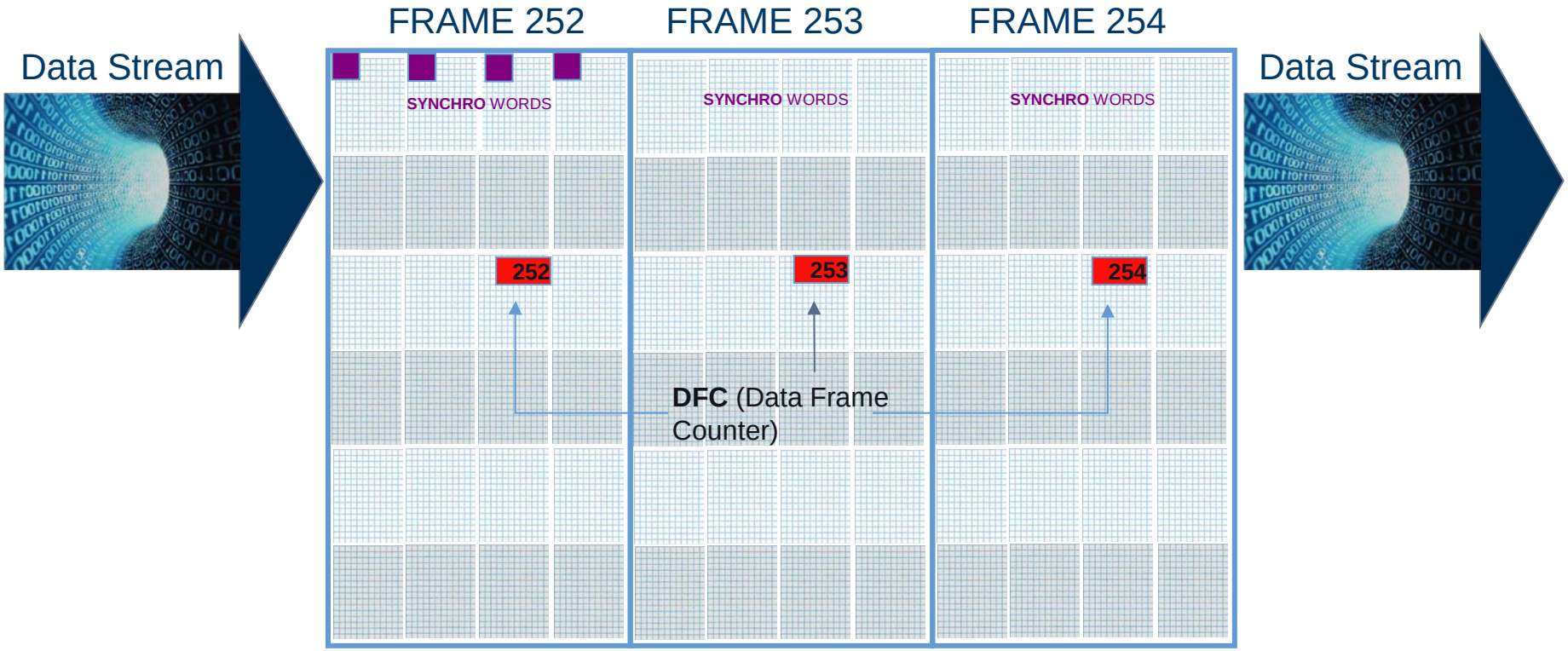
FDA Limits – What does recorded Data look like ?

Each word is made of 12 bits.
These bits contain the active parameter data
One word can contain several parameters



FDA Limits – What does recorded Data look like ?

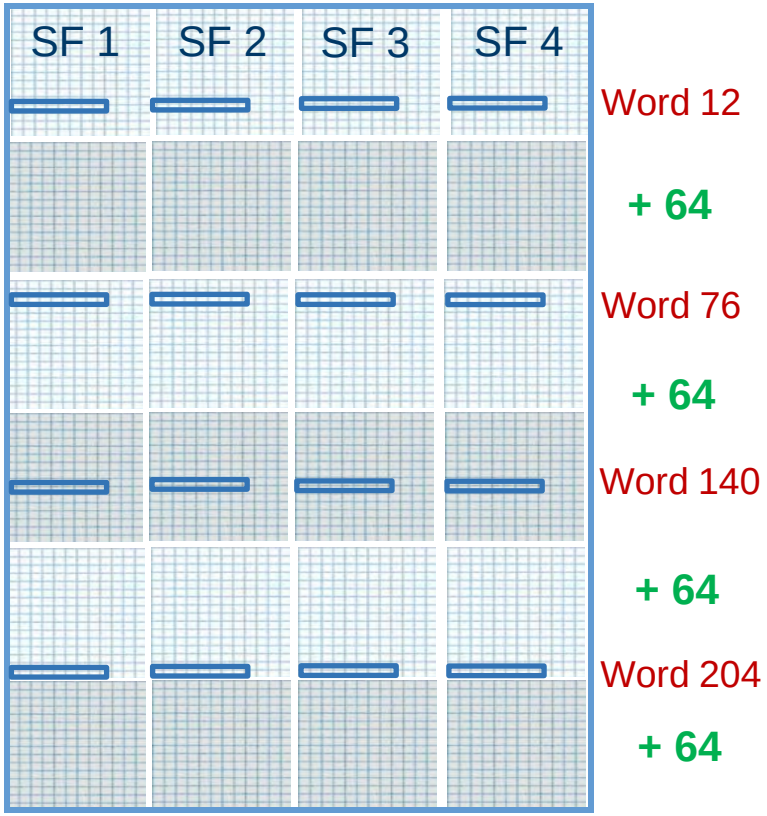
The stream is managed by synchronisation words and a data frame counter which provide the continuous assessment capability on the stream.



FDA Limits – What does recorded Data look like ?

According to its refreshing rate parameter can be stored several times in one frame. Done at a constant pace.

Example : FRAME **256 WPS**

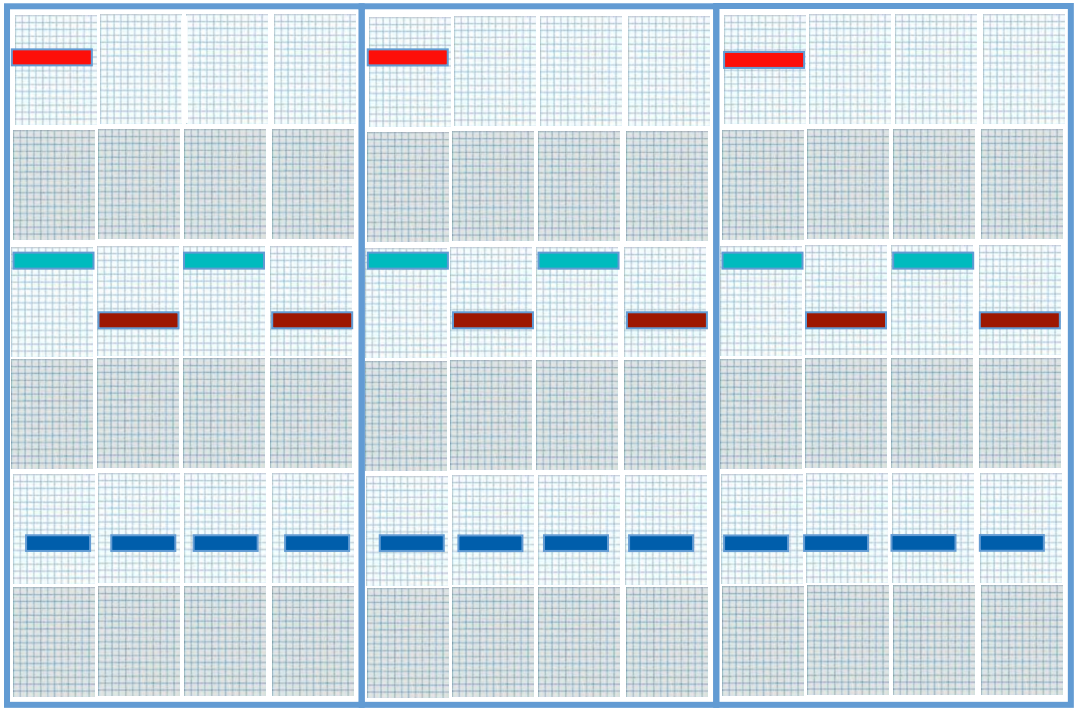


4 Hz

FDA Limits – What does recorded Data look like ?

Data Stream

Data Stream



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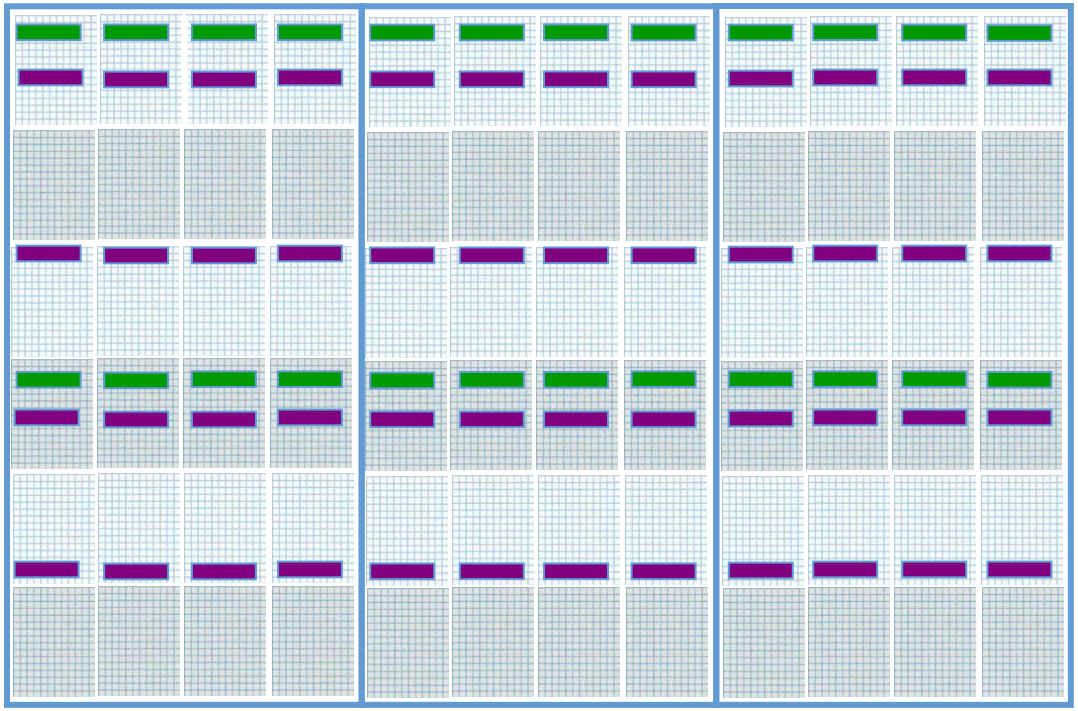
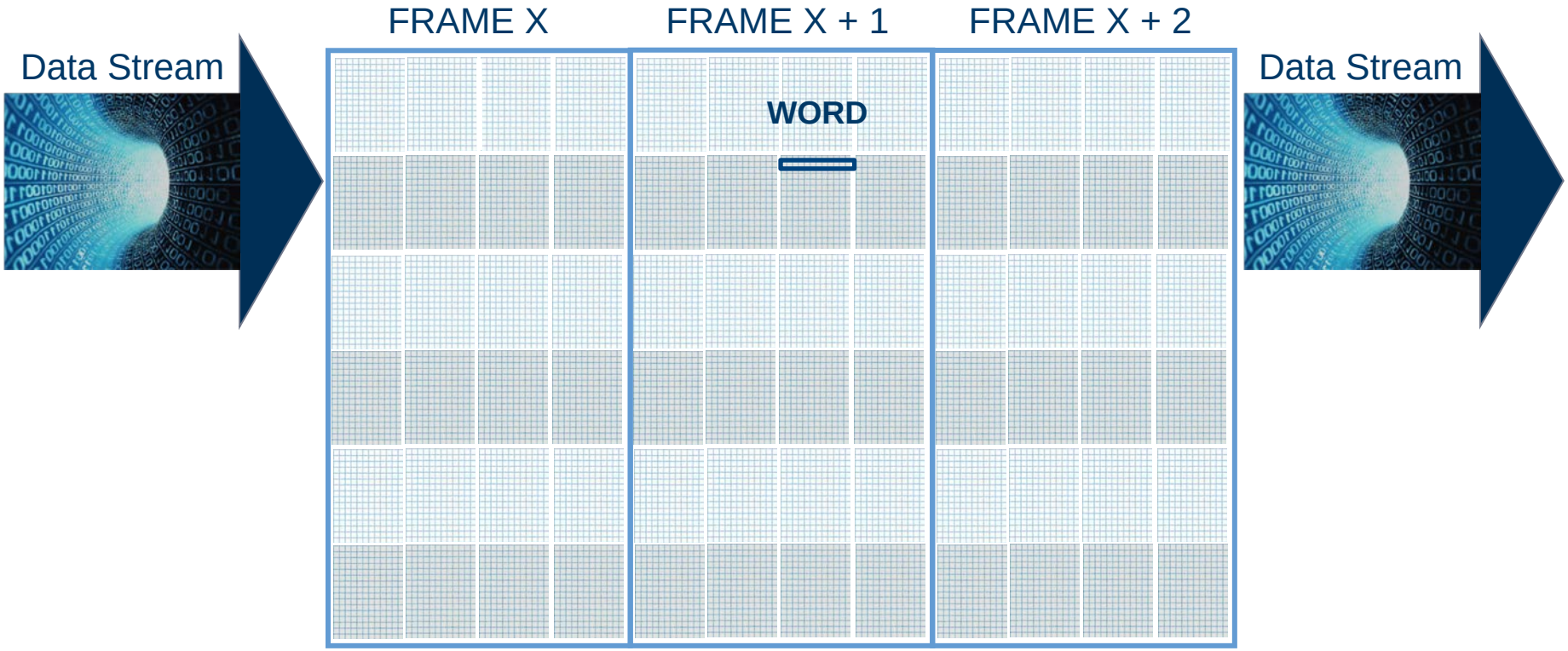


FDA Limits – What does recorded Data look like ?

Some words do not need to be recorded on each Frame.
They are therefore recorded every Superframe.



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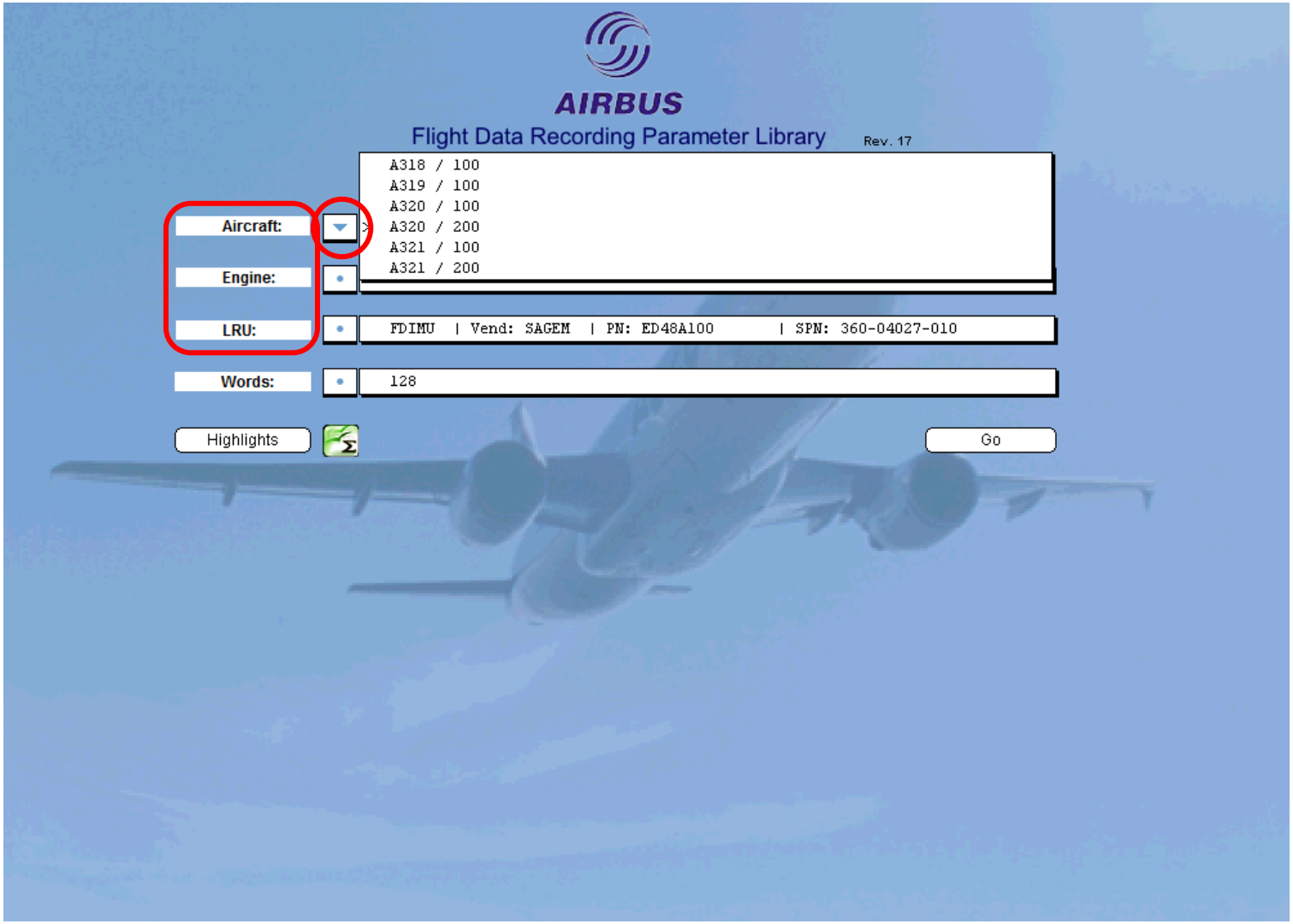

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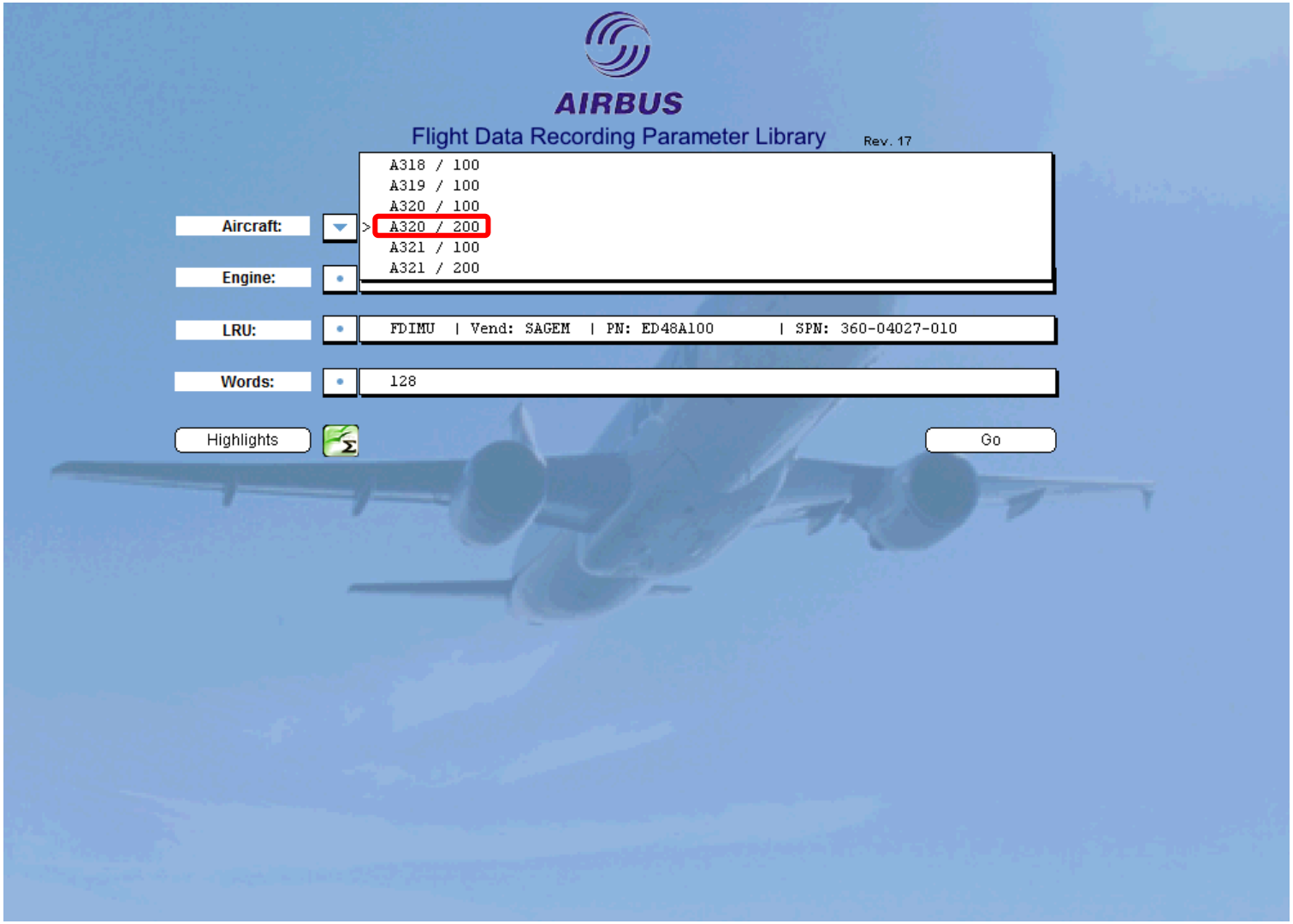

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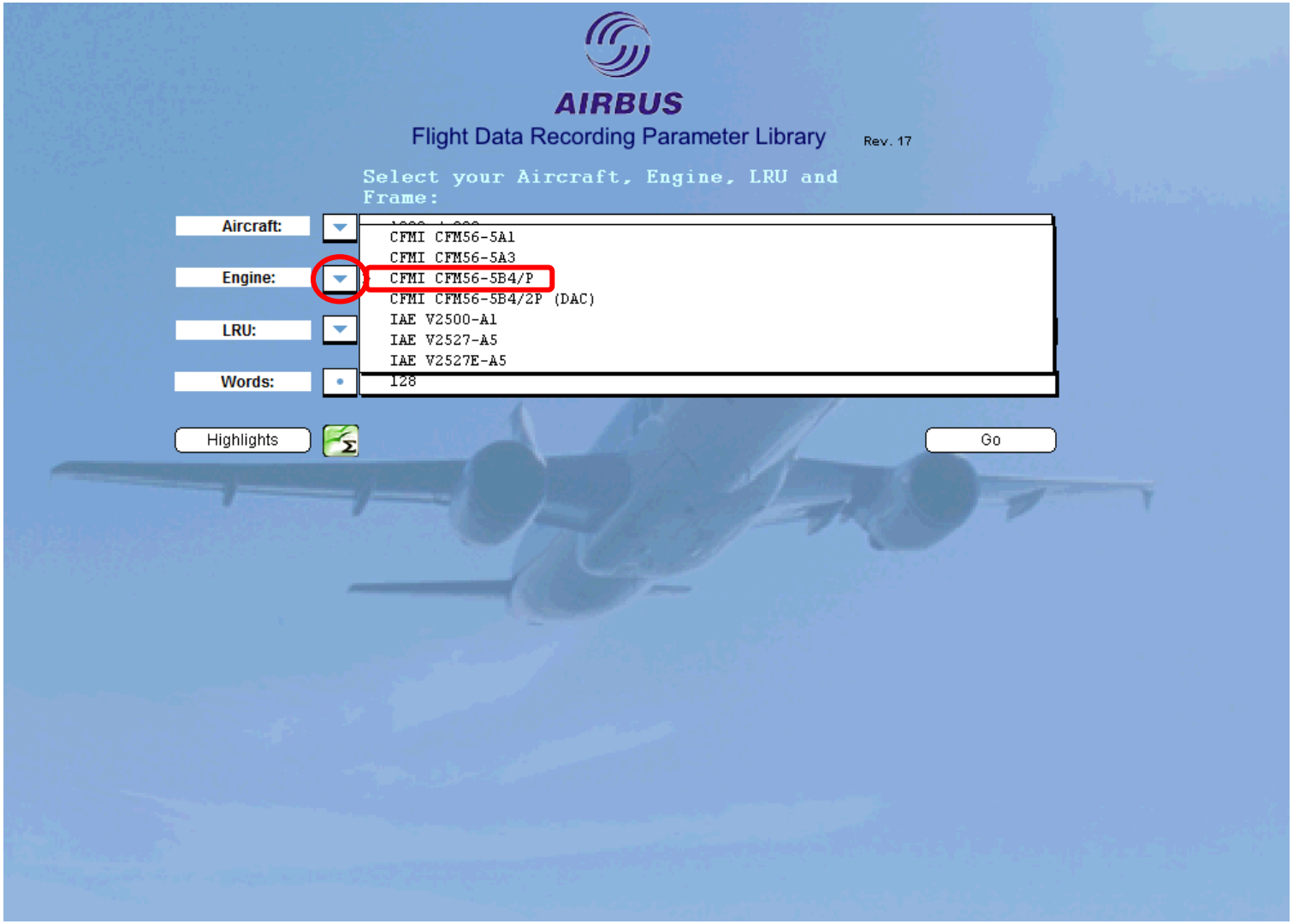

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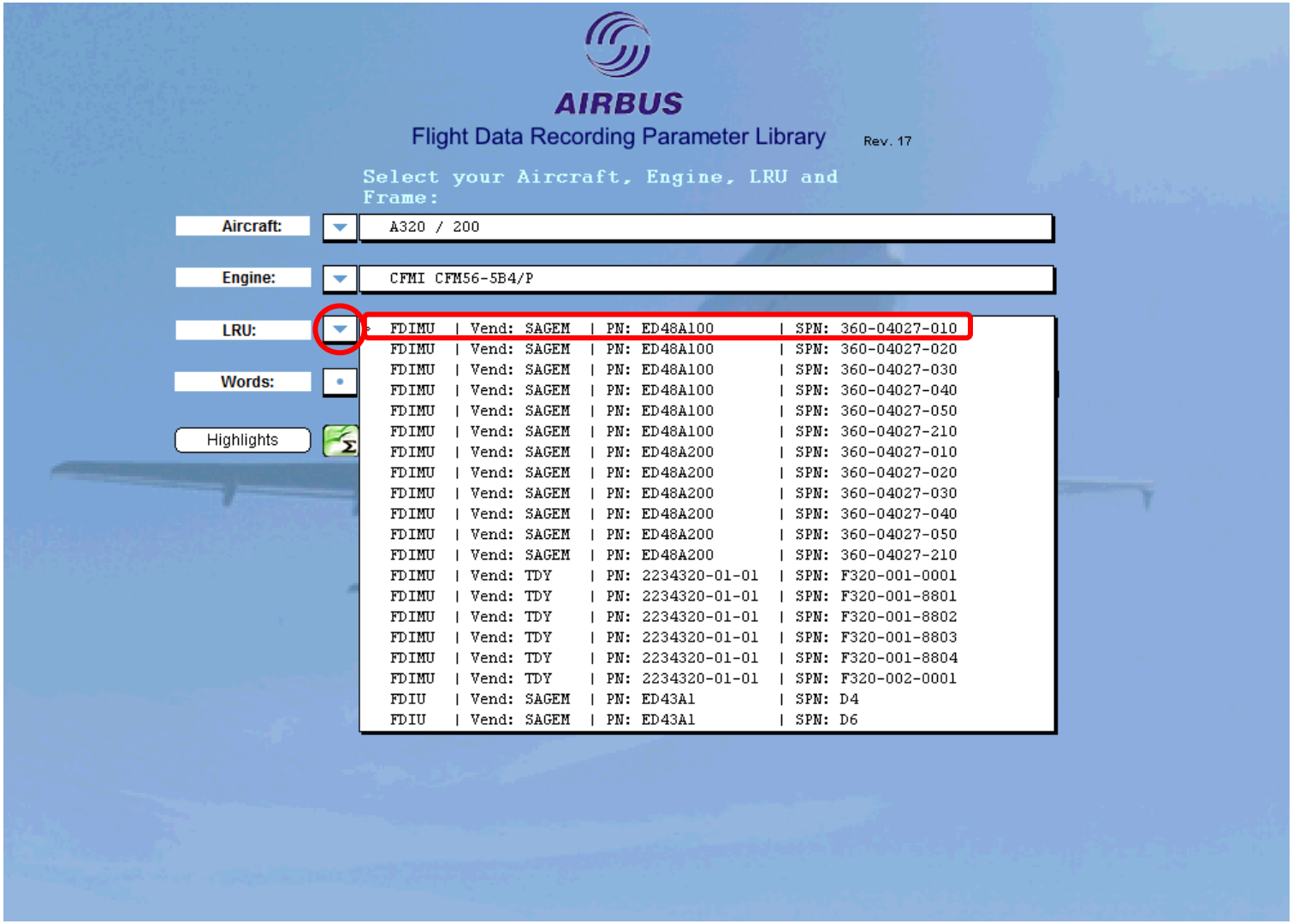

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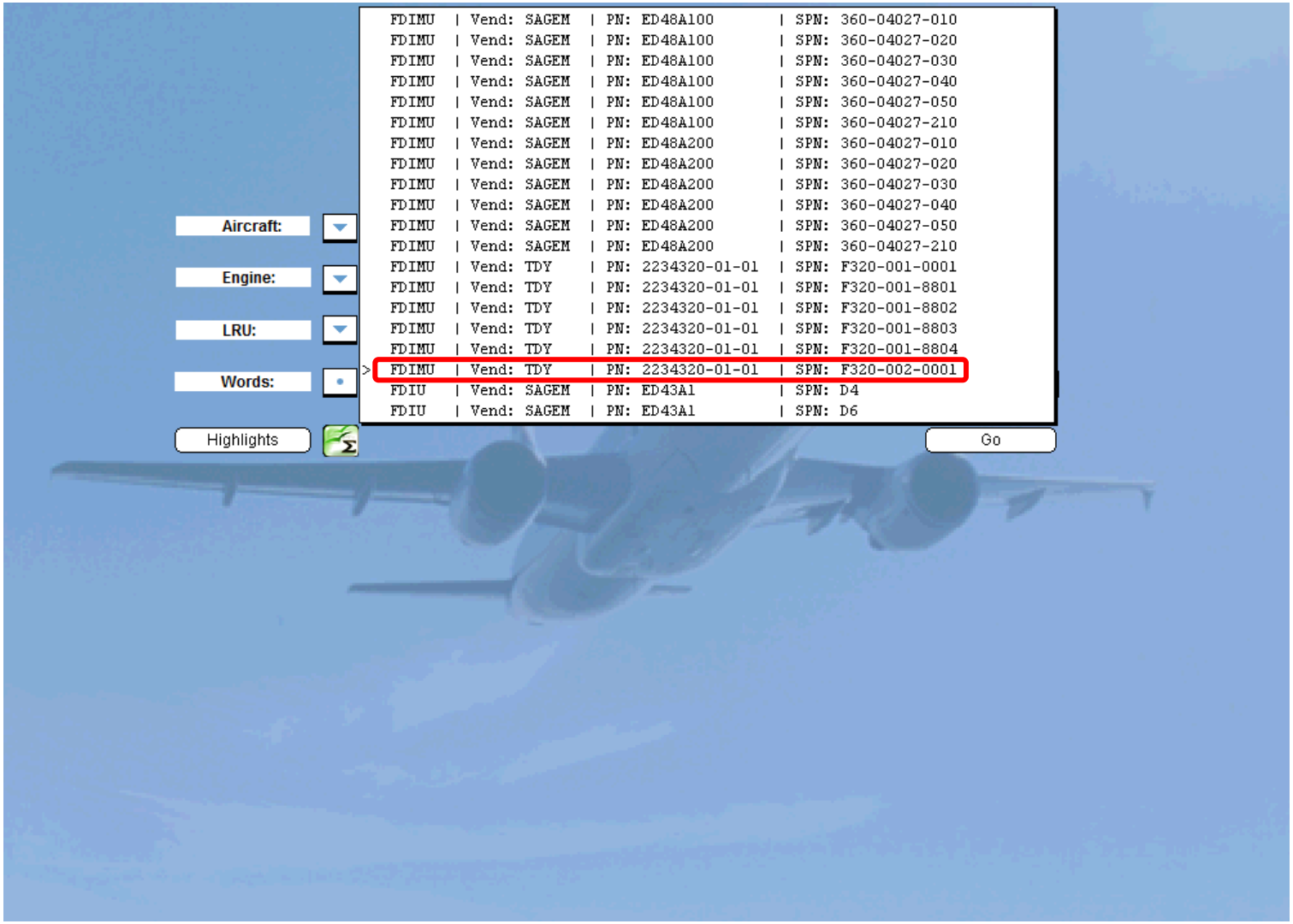

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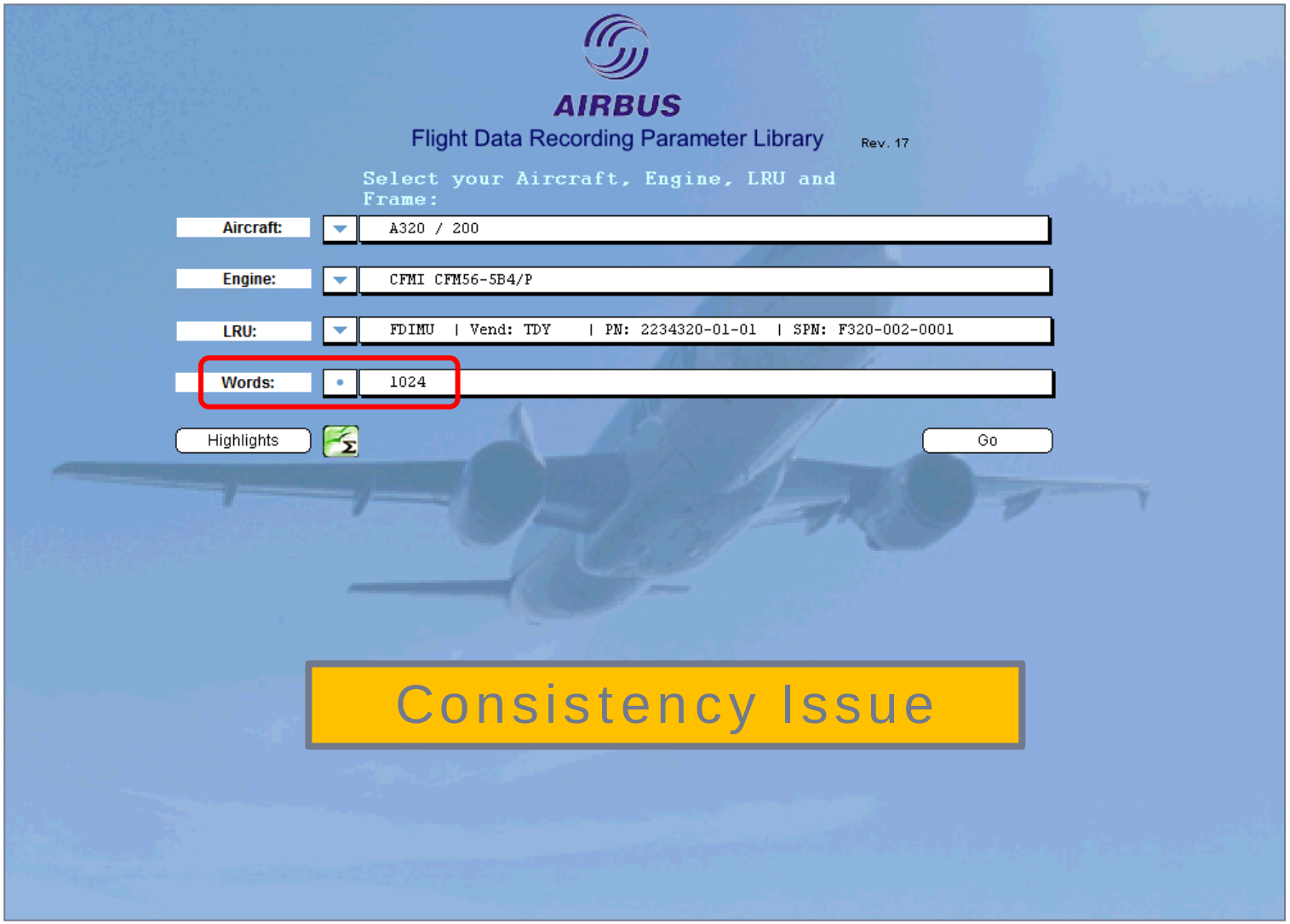

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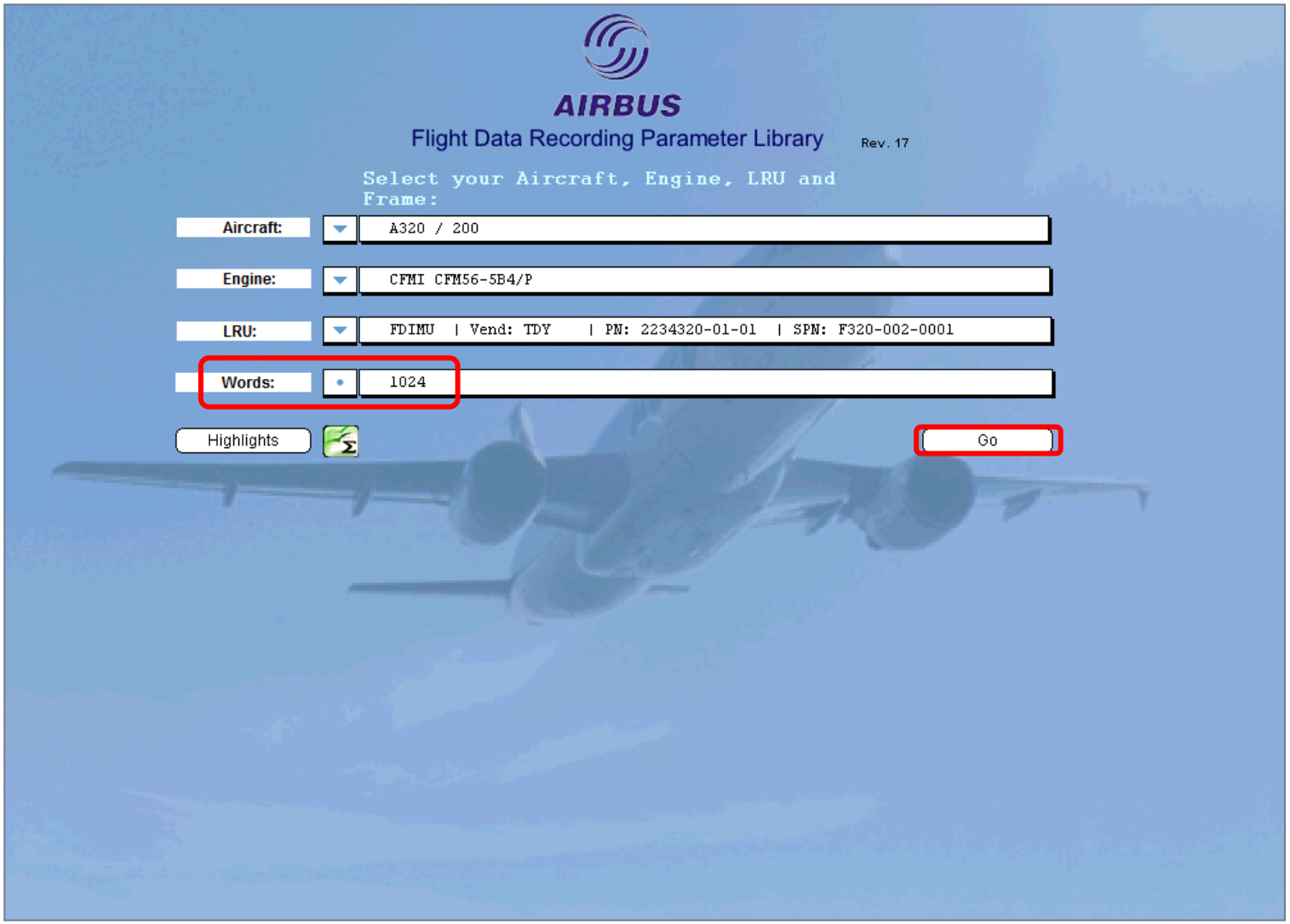

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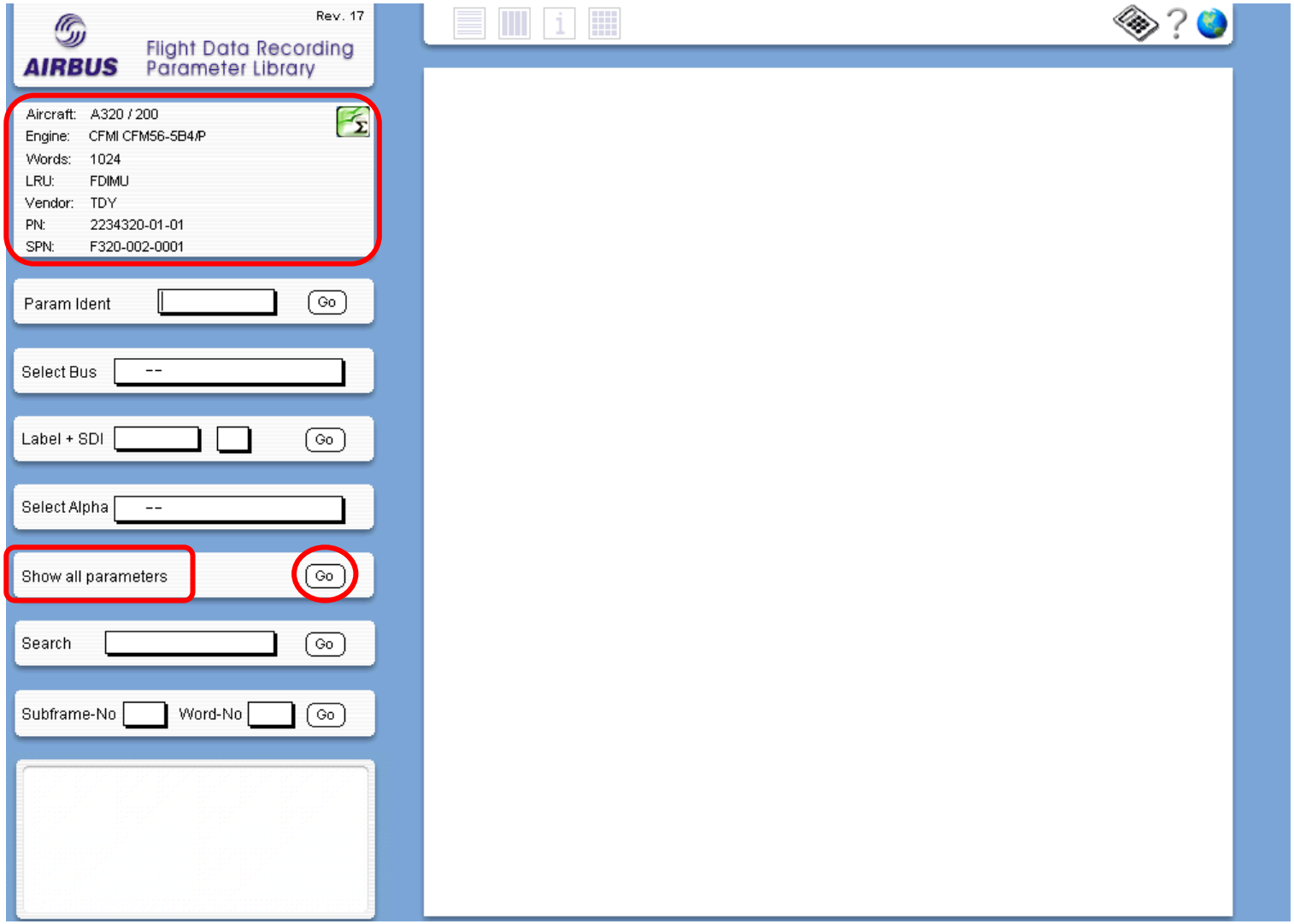

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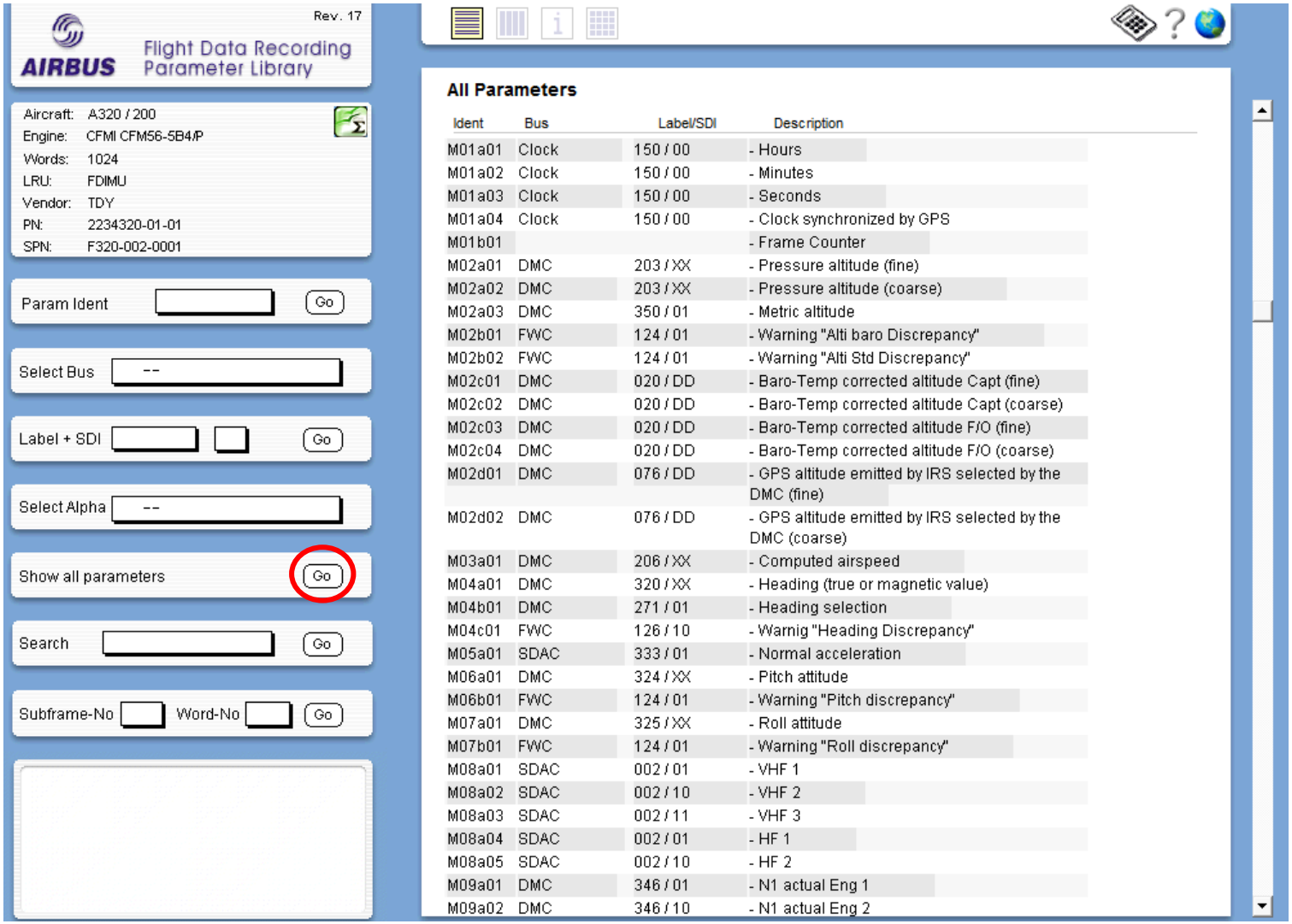

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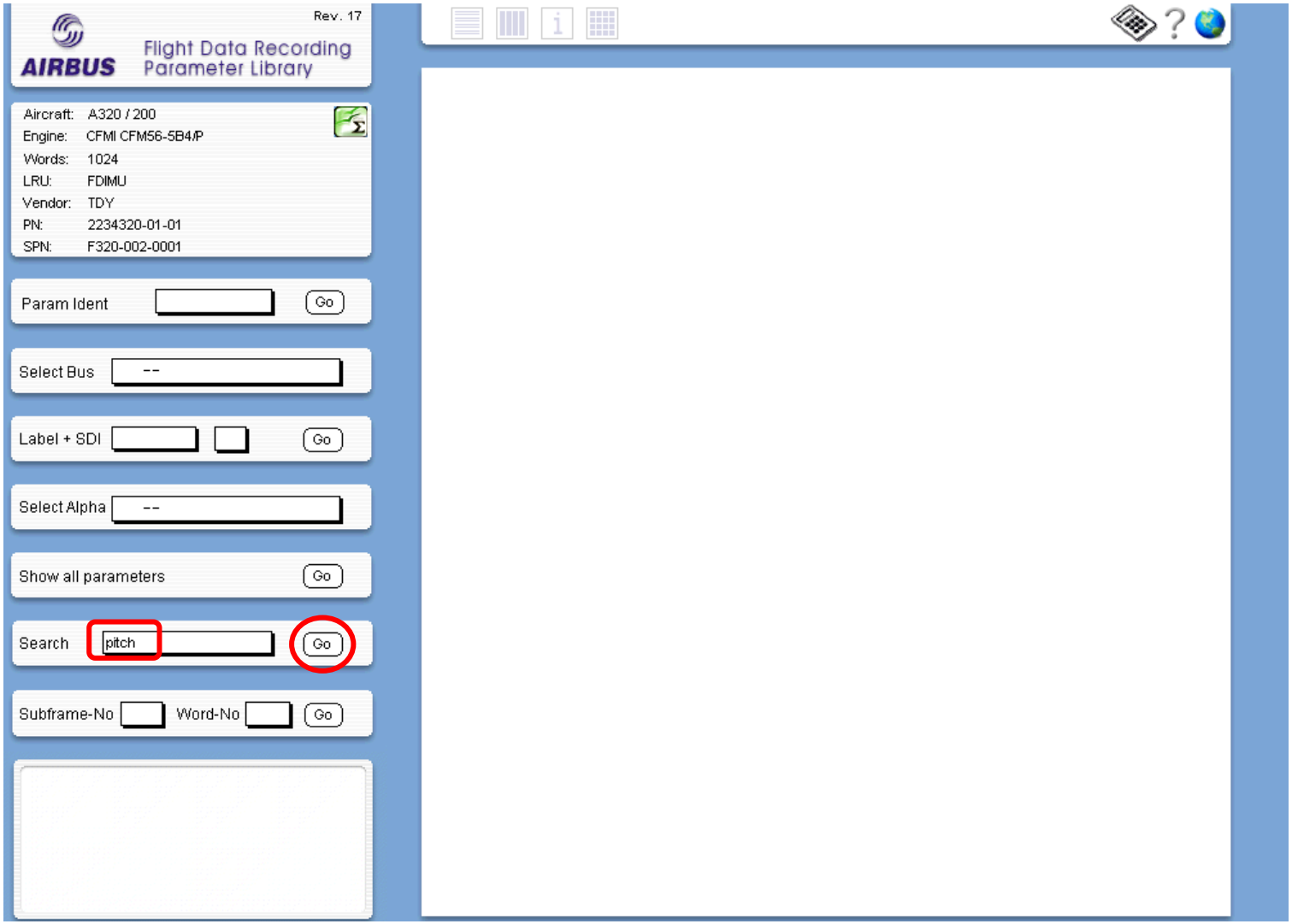

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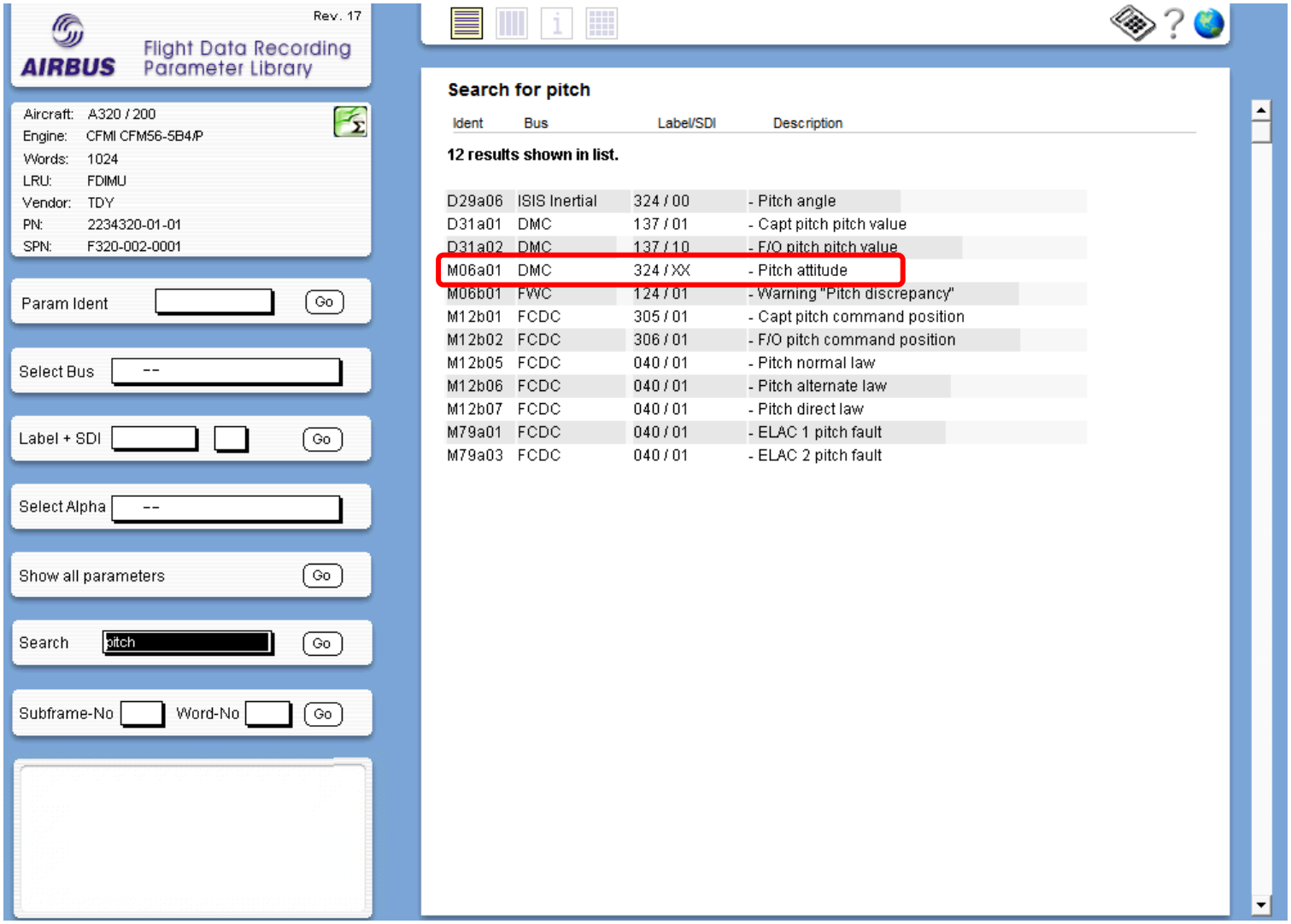

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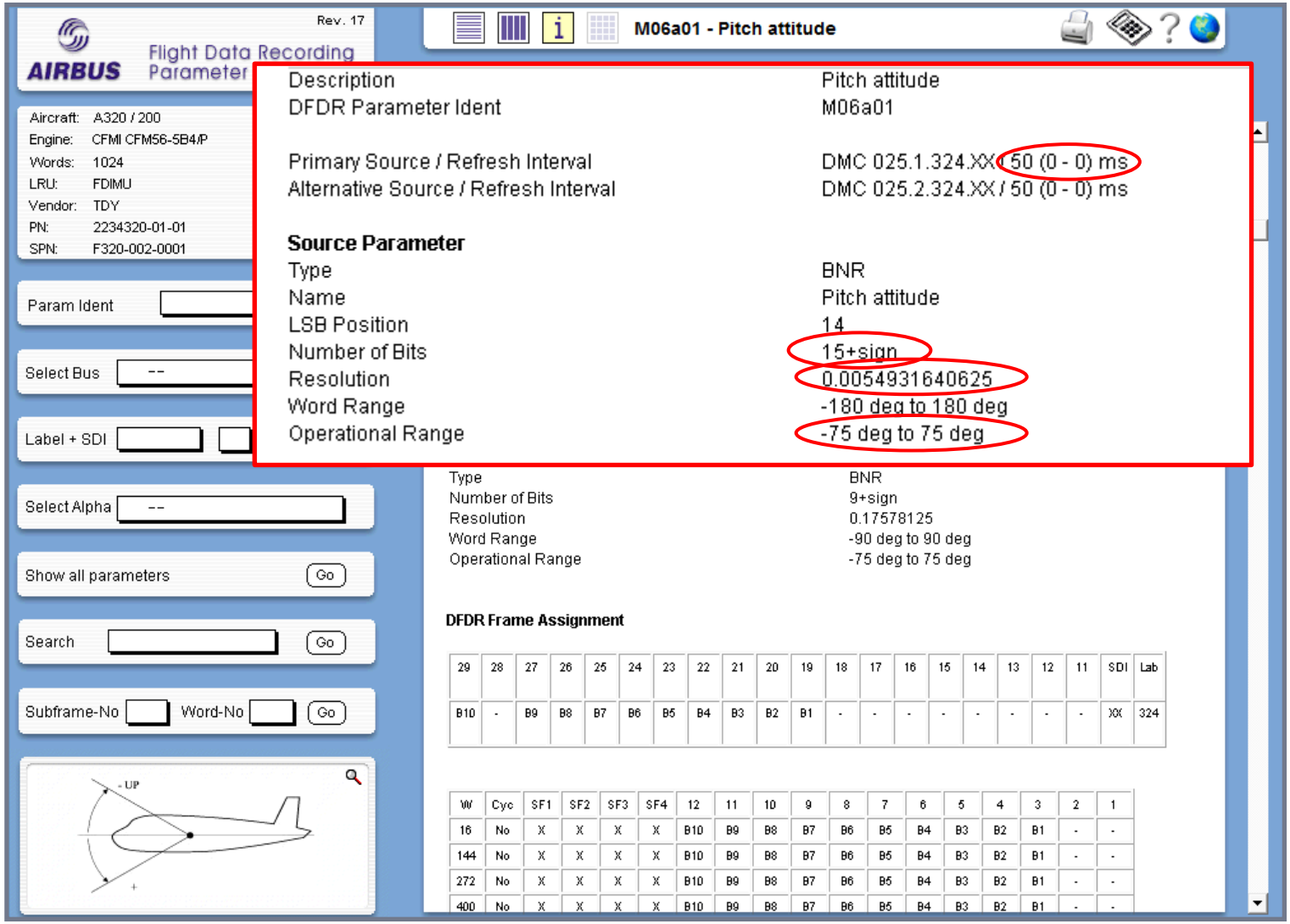

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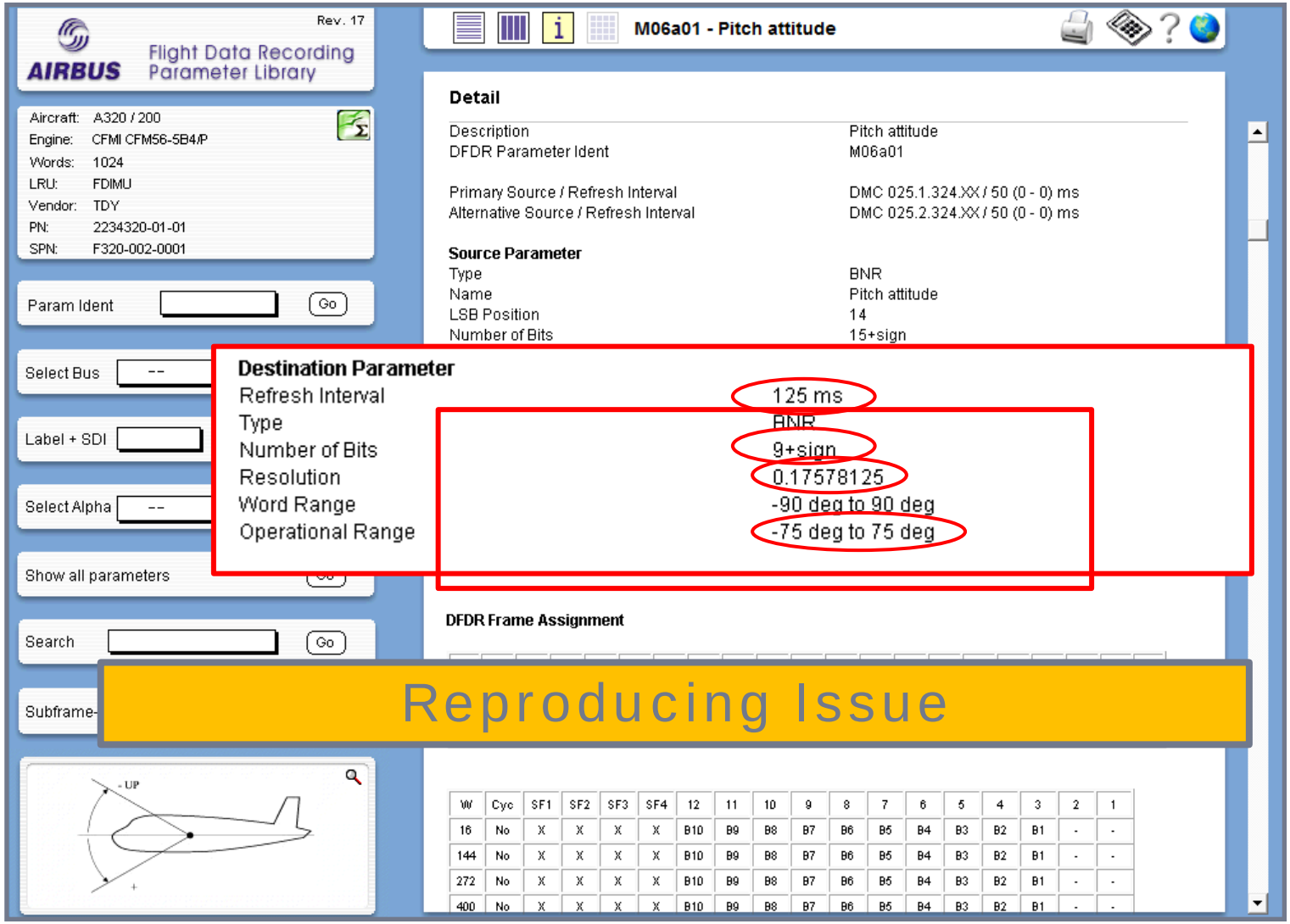

FDA Limits - Content

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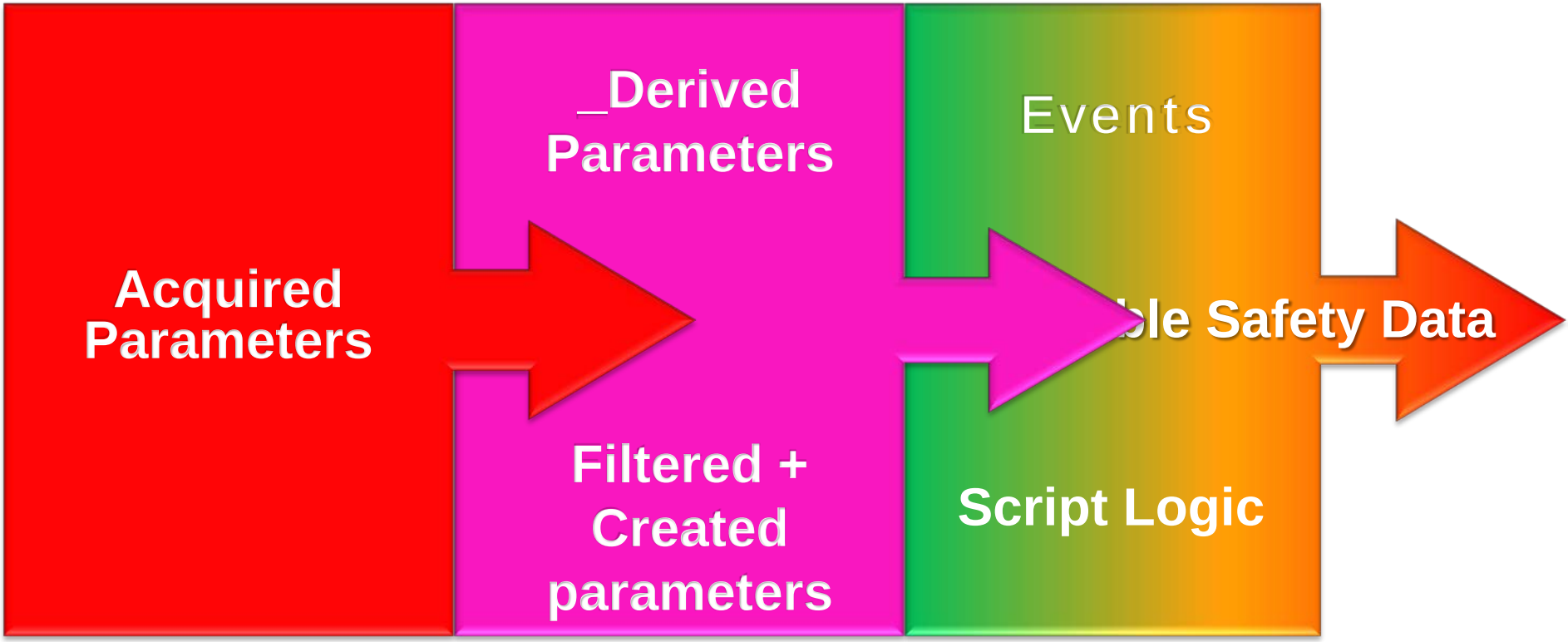
FDA Limits - How to make it readable?

The Purpose of FDA Tool is to

Identify Non-Desired flight conditions



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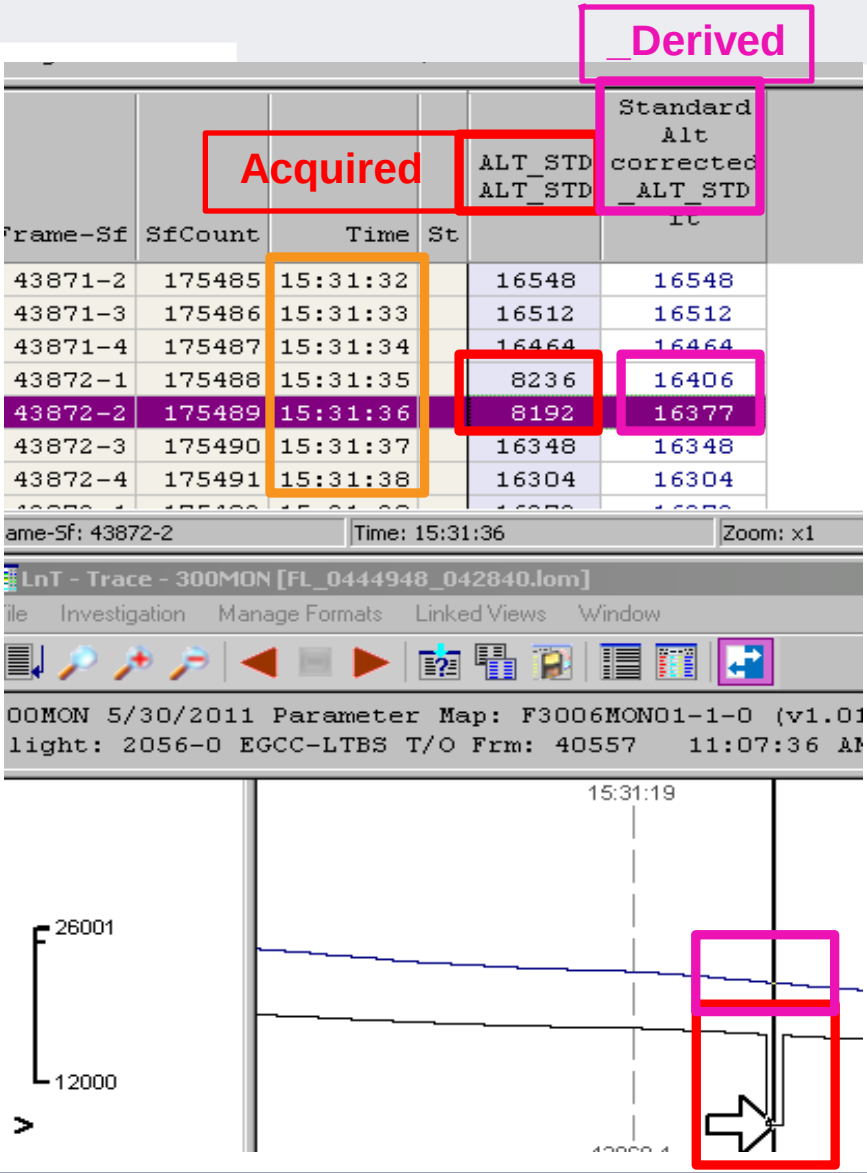
FDA Limits - How to make it readable?

Acquired Parameters must be _Derived to become exploitable

This derivation allows:

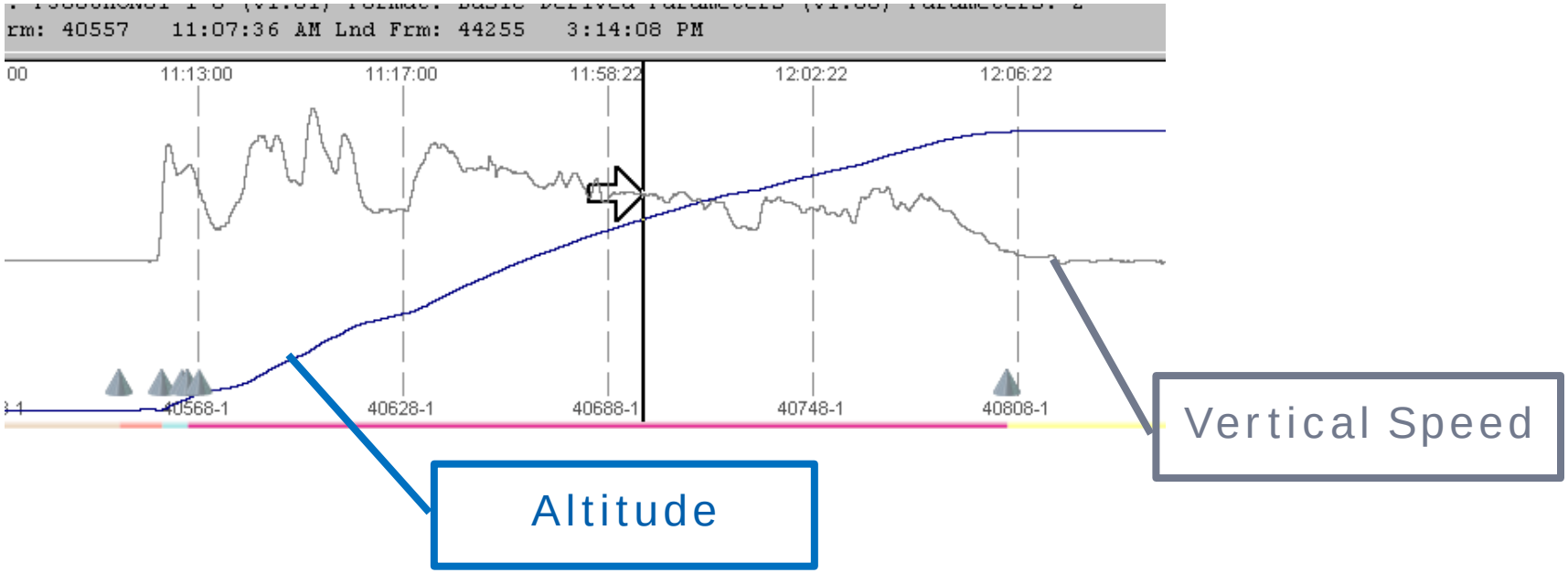
- Automatic wrong parameter filtering



FDA Limits - How to make it readable?

Derivation also allows new parameter development

example: vertical speed derived from altitude



FDA Limits - How to make it readable?

Parameters can be derived rather simply

Boolean Example

0 = FALSE

1 = TRUE

_Derived Parameter = Acquired Parameter

FDA Limits - How to make it readable?

Parameters can be more complex

Binary Example

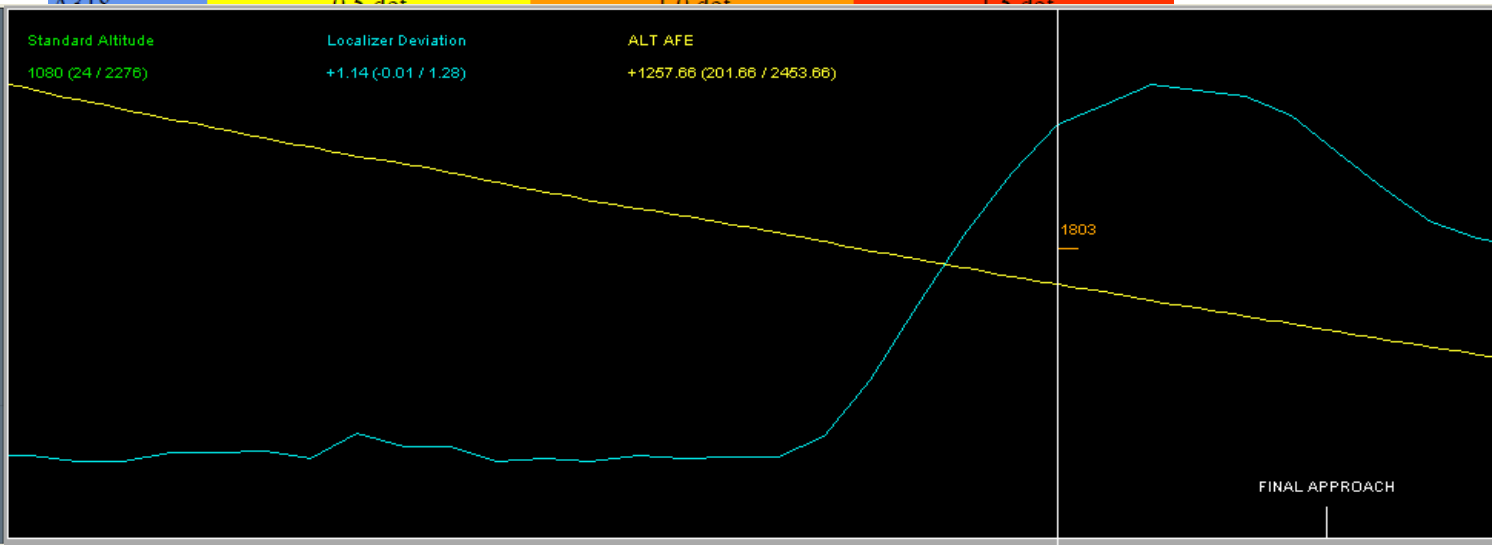
_Derived Parameter
=
Acquired Parameter x Coefficient
+
Offset

AIRBUS

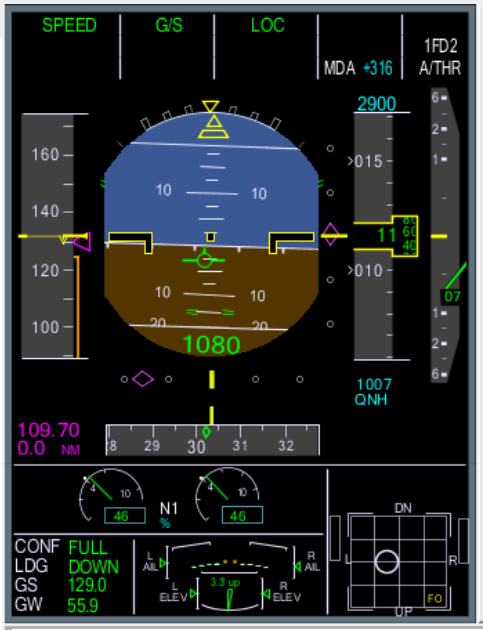
FDA Limits - How to make it readable?

Ex: Deviation from Localizer

	|LOCC| >: TOL >= 3s		
A/C Type	LOW	MEDIUM	HIGH
A300-600	0.5 dot	1.0 dot	1.5 dot
A310	0.5 dot	1.0 dot	1.5 dot
A318	0.5 dot	1.0 dot	1.5 dot



FDA Limits - How to make it readable?



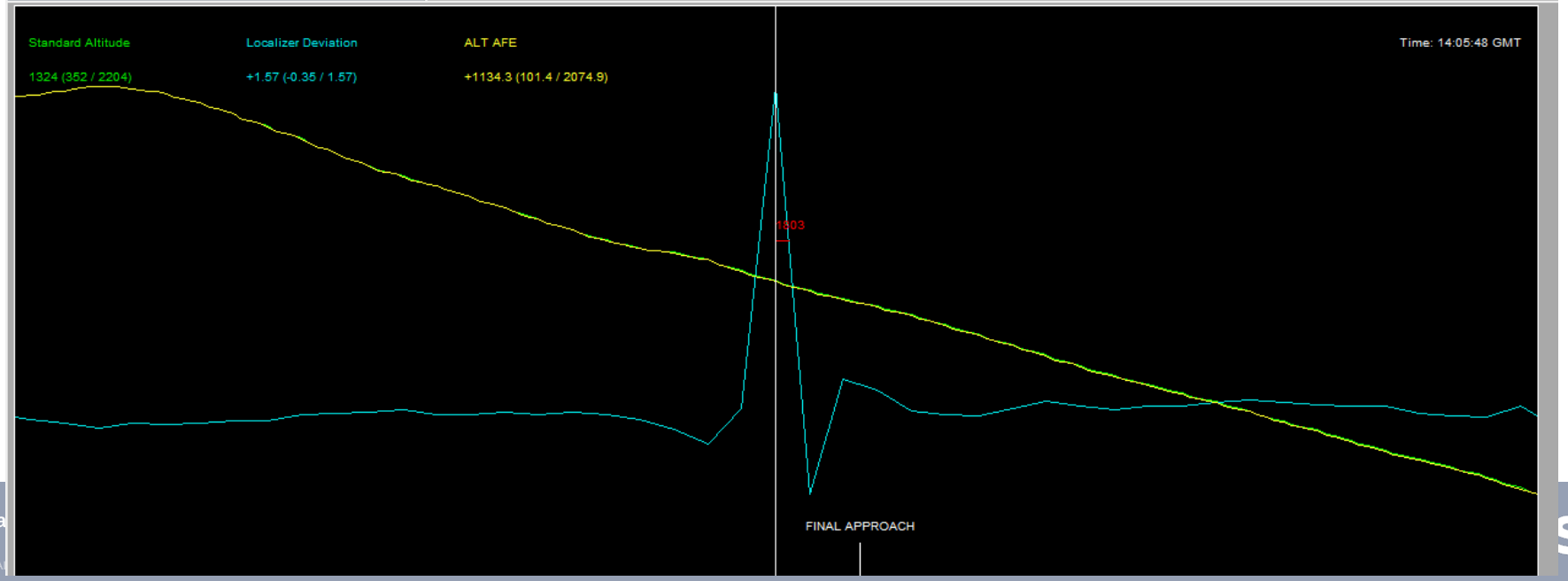
Events | Flight Phases | 3D | Configuration | Airport

Single Events

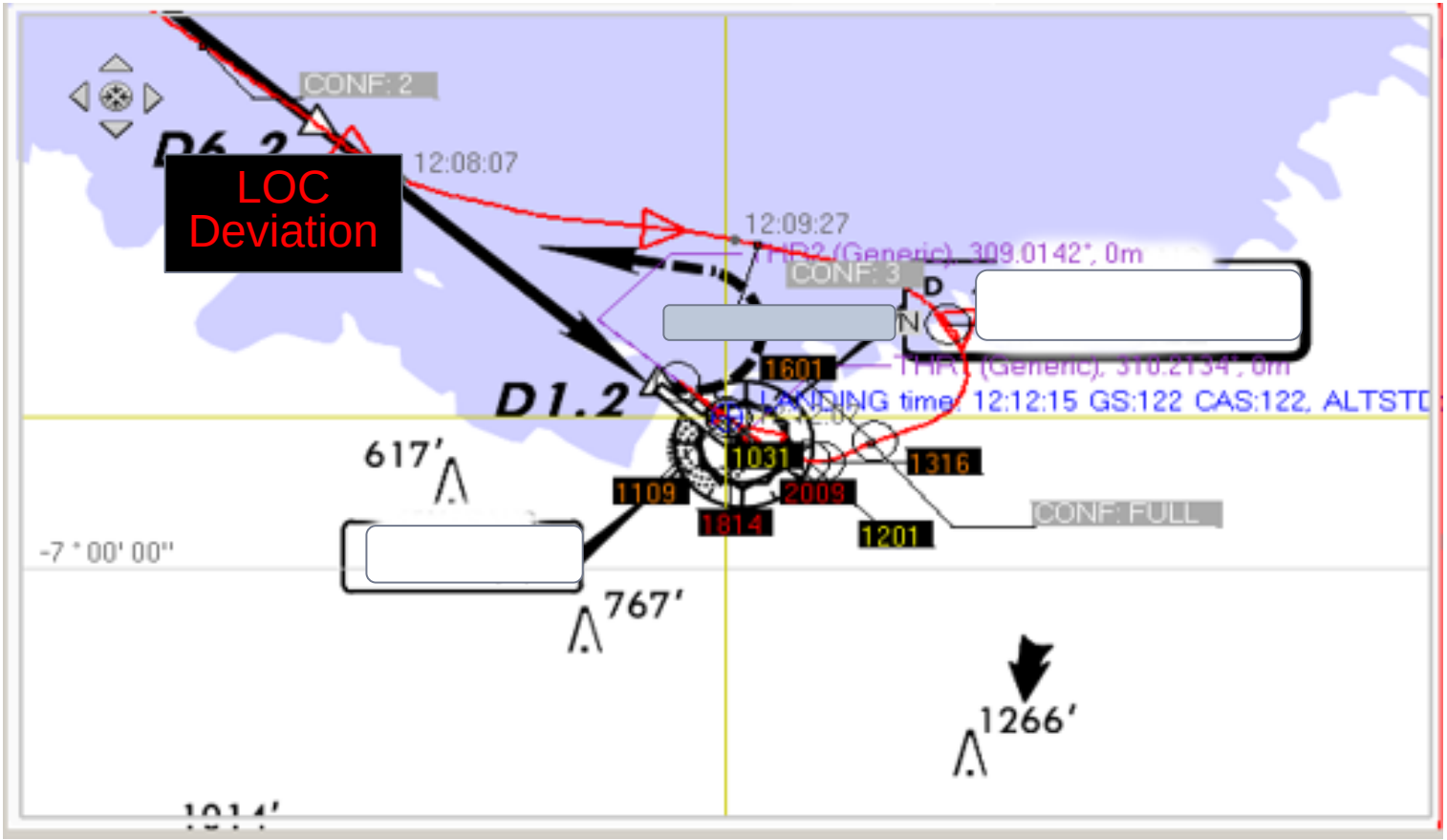
Event	Time /	Description	Unit	Low	Medium	High
1030	01/05/2008 10:22:09 GMT	Taxi Speed Exceedance	GS	> 32 Kts	> = 35 Kts	> = 40 Kts
1053	01/05/2008 10:23:53 GMT	Rolling take-off				
1803	01/05/2008 14:05:48 GMT	Deviation from Localizer	|LOCC| >: TOL >= 3s	0.5 dot	1 dot	1.5 dot
1023	01/05/2008 14:07:36 GMT	Low Speed at Landing	CAS <:	VLS -5 Kts	VLS -8 Kts	VLS -10 Kts
1818	01/05/2008 14:07:36 GMT	Long Touchdown	DIST_TO_THR (at TD)	750 m	900 m	1050 m
1619	01/05/2008 14:07:53 GMT	Reversers Abusive Use	Full reverse applied with CAS <	65 kts	55 kts	45 kts

Trend Events

Event	Time	Description



FDA Limits - How to make it readable?



FDA Limits - How to make it readable?

Limitation

- Parameter reliability
- Script logic revelency

Solution

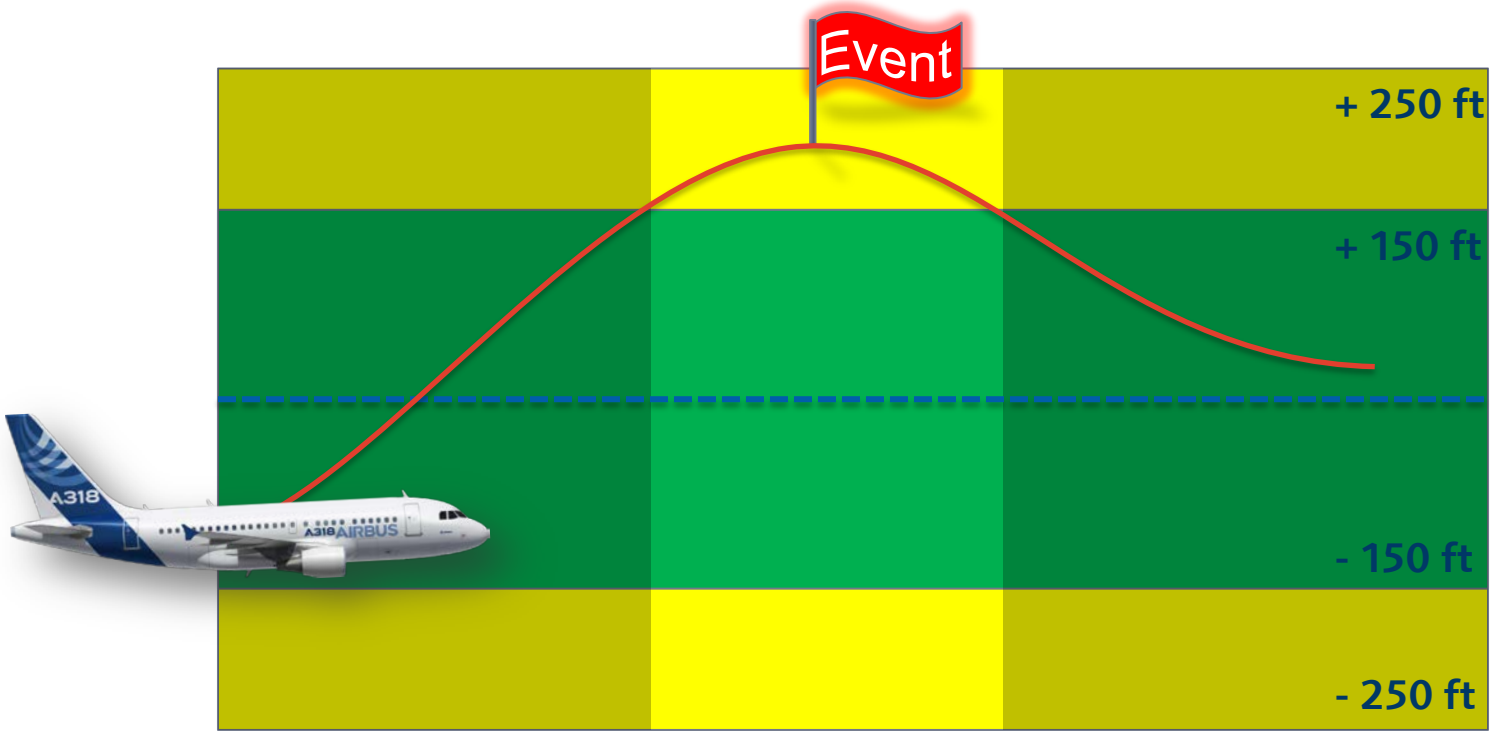
- Engineering cleaning
- Operational cleaning

An FDA software is partially DUMB

FDA Limits - How to make it readable?

Ex: Level Bust

Event raised when entering and escaping the zone



FDA Limits - How to make it readable?

Limitation

- Inside and Outside Voice messages not available

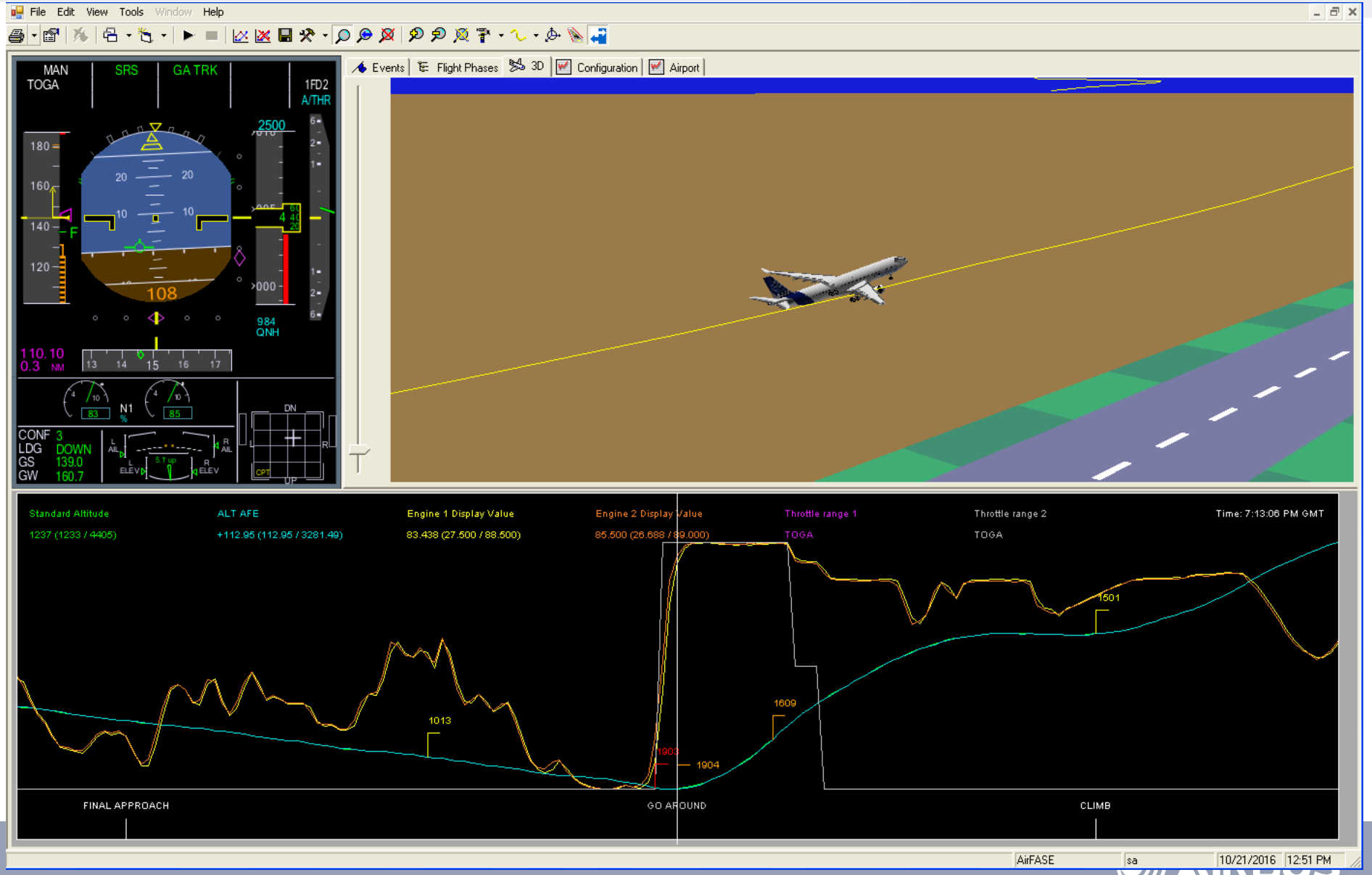
Solution

- To create a close Link with the reporting system

An FDA software is partially DEAF

AIRBUS

FDA Limits - How to make it readable?



FDA Limits - How to make it readable?

Limitation

- No Environmental/Situational Information

Solution

- To use any available data, including the reporting system

An FDA software is partially BLIND

FDA Limits - Conclusion

The FDA tool is very powerful,

Even if it has some limits

It will tell you

WHAT happened,

but not WHY it happened…

An FDA tool needs Human Expertise