AAIB SAFETY RECOMMENDATION
EMBRAER 145 DFDR PERFORMANCE

Background

On the 16 February 2002 a British Midland Embraer 145, registration G-RJXC, en route from Leeds to Paris developed hydraulic problems and diverted into East Midlands Airport. When full flap was deployed the left outboard spoiler opened and resulted in the handling pilot requiring to use almost full roll trim and in excess of 75% of the available control wheel to maintain wings level attitude. When the DFDR was replayed it was noted that data sampled at greater than one sample per second appeared not to have been updated at the appropriate time, in that a series of identical values were recorded. An alternative reason for the repeated samples was that the recorded resolution was inadequately low and variable in extent. Examples of this are provided in the attached graphs (figures 1 & 2) and the data listing (figure 3). The data used to produce figures 2 & 3 are identical. It is possible that data sampled less frequently are similarly affected, but anomalies in the recording of data sampled at 1 sample per second are difficult to identify by inspection.

The AAIB has been involved in four other incidents to Embraer 145 aircraft of both British Midland and British Regional, and has data from 2 other routine downloads. All of these recorders exhibited similar faults. The inference must therefore be that the same problem exists on all Embraer 145 aircraft.

The anomalies were discovered by detailed inspection of the data, it is unlikely that the problems would be picked up by the current routine replay system.

Recording anomalies

Figure 1 shows a time history of selected parameters recovered from the DFDR fitted to G-RJXC recorded during the incident landing. Pitch Attitude and Lateral Acceleration are sampled at 0.25 second intervals, Normal Acceleration at 0.125 second interval, Roll Attitude at 0.5 second interval and Altitude, CAS, Groundspeed and Heading at 1 second intervals.

Figure 2 shows the data recorded during the "flare" in an expanded form and figure 3 shows similar data in the form of a numerical listing. The stepped nature of the time histories and the number of times a data sample is repeated are inconsistent with the dynamic conditions that existed immediately before the aircraft landed. Of concern is the repetition of the same data value. In one of the other incidents a Normal Acceleration value remained constant for 34 samples (in excess of 4 seconds) whilst the aircraft was flaring. This repetition of values is an indication that the

resolution in recording is variable and inadequately low. It is possible that the samples are not being updated as they should be and this is causing the effective inadequate resolution.

International standards require that the resolution of Normal Acceleration should be better that 0.004G. The EMB145 documentation indicates that the system is designed to provide a resolution of 0.0046G. Inspection of the recorded data samples at figure 3 show that neither the design nor the regulatory resolution is being met. As far as can be determined all parameters with sampling rates greater than 1 sample per second are affected. These are:-

      Normal Acceleration

      Lateral Acceleration

      Longitudinal acceleration

      Pitch Attitude

      Roll angle

      Pitch control position

      Roll control position

      Yaw Control position

Whilst it is certain that there are errors in the recording of the above parameters. It is also possible that anomalies exist in parameters recorded at 1 sample or less per second. In particular Groundspeed appears on many occasions to be incompatible with recorded airspeeed. Figure 2 shows possible repeated data values and a marked difference in the values of CAS and Groundspeed in conditions where there was no headwind component. On occasion the recorded engine N1 speed and Altitude also appear to be incompatible with the designed resolution and sampling rate.

Conclusion

All of the recorders handled by AAIB have shown a similar problem. This leads us to believe that recording systems on all Embraer 145 aircraft are faulty. The parameters most affected seem to be those recorded at greater than once a second sampling rate. These include such parameters as the accelerations, the aircraft attitudes, and control positions. If, for example, it is necessary to accurately determine the correct aircraft response for given control inputs this would be impossible with the current installed Flight Data Recording system. The system must be regarded as inadequate for its task and therefore the AAIB make the following recommendations.

Recommendation 2002-01

As a matter of urgency, the Centro Tecnico Aeroespacial (CTA) of Brazil should require Embraer and the manufacturers of the flight data recording installation to investigate the nature and extent of the recording anomalies associated with the EMB145 DFDR installation, to correct them on existing and future aircraft, and subsequently demonstrate that the DFDR faithfully records the time histories of the data transducer outputs. The CAA as part of its JAA activities should monitor this process.

Recommendation 2002-02

The CAA should liase with Embraer to ensure that the DFDR installations on all UK registered Embraer aircraft meet applicable UK regulatory requirements
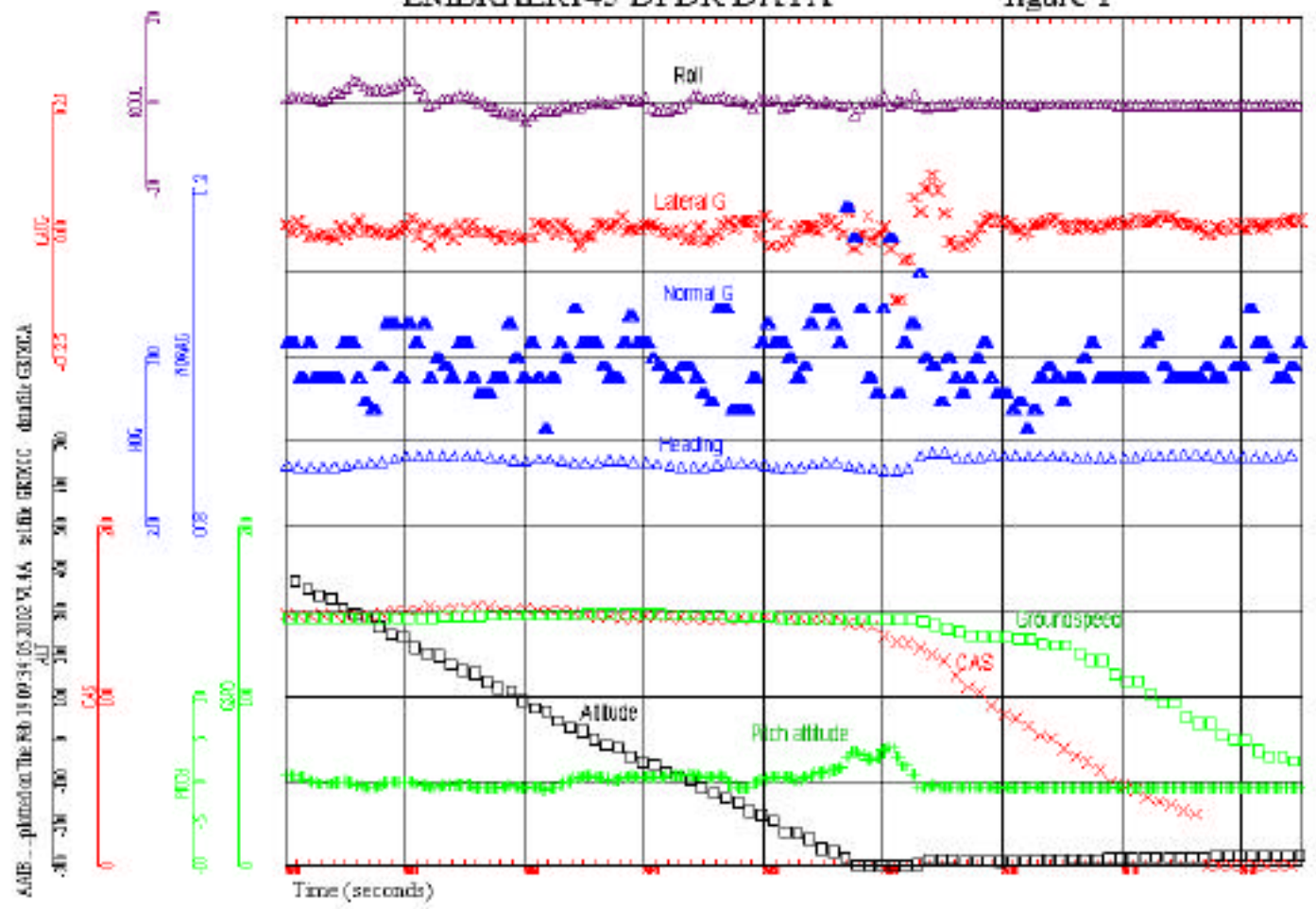
Recommendation 2002-03

The CTA of Brazil should bring the EMB 145 DFDR anomalies to the attention of other national regulatory authorities

Recommendation 2002-04

The CAA should ensure that other aircraft types operating on the UK register and fitted with similar flight data recording installations meet, UK regulatory requirements.
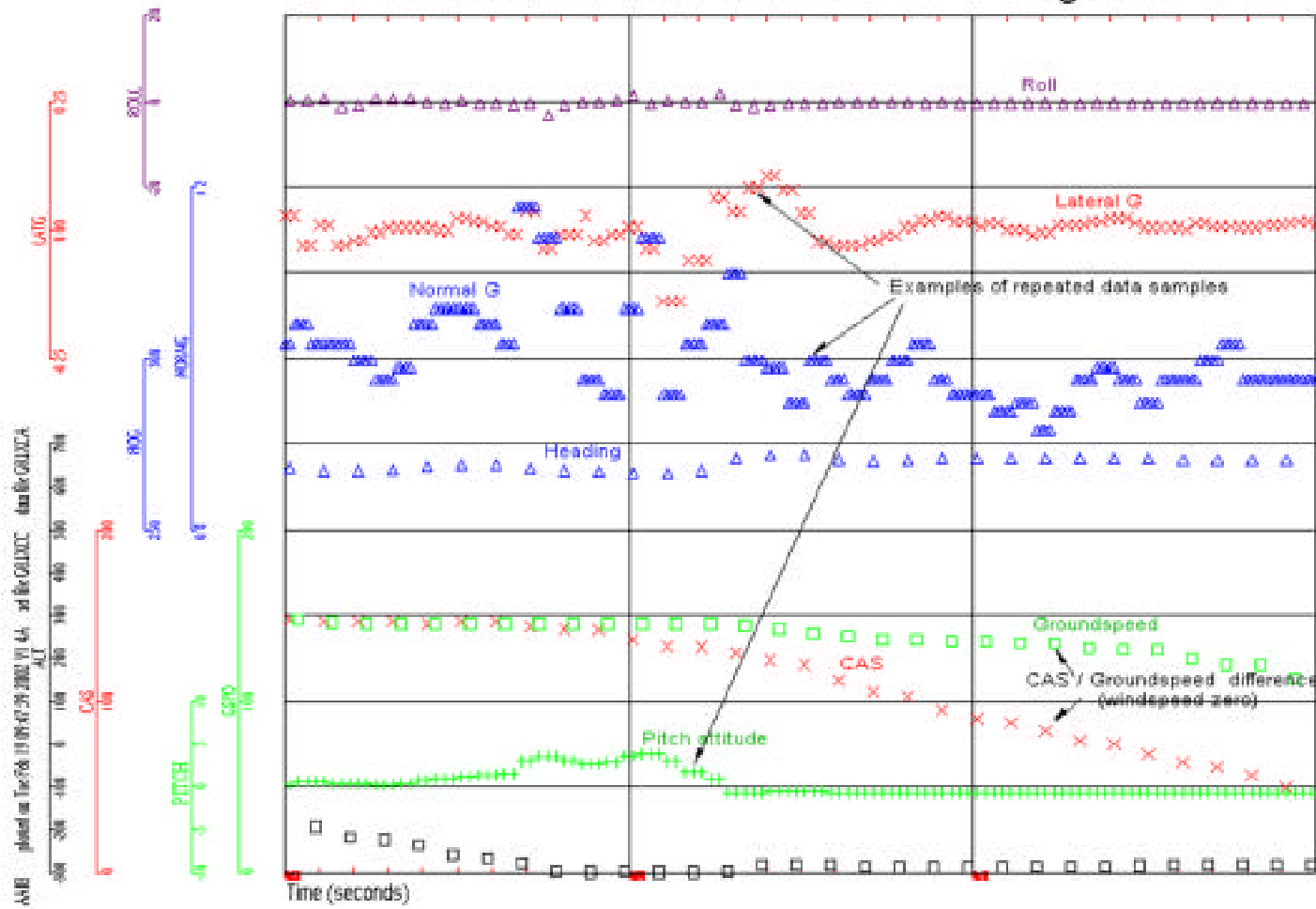
EMBRAER145 DFDR DATA　　　figure 1

Roll

Lateral G

Normal G

Heading

Groundspeed

CAS

Altitude

Pitch attitude

Time (seconds)

EMBRAER145 DFDR DATA   figure 2

EMB-145 G-RJXC SELECTED DATA LISTING   **Figure 3**

Subframe count	ALT (FEET)	LATG (G)	CAS (KT)	HDG (DEG)	ROLL (DEG)	PITCH (DEG)	NORMG (G)	GSPD (KT)	SYNC
96086		0.007128					1.03969		3
96086.13			146.572	268.813	-0.43967	1.319	1.03969		3
96086.25		0.007128					1.01679		3
96086.38						1.5828	1.01679	145	3
96086.5		-0.00815					1.01679		3
96086.63					-0.70347	1.5828	1.01679		3
96086.75		-0.00815					1.1771		3
96086.88	-280					2.98974	1.1771		3
96087		0.034623					1.1771		4
96087.13			143.57	267.934	-0.35173	2.98974	1.1771		4
96087.25		0.034623					1.1771		4
96087.38						3.51734	1.14046	145	4
96087.5		-0.03768					1.14046		4
96087.63					-3.07767	3.51734	1.14046		4
96087.75		-0.03768					1.14046		4
96087.88	-299					3.51734	1.14046		4
96088		-0.00815					1.05801		1
96088.13			142.069	267.318	-0.96727	3.07767	1.05801		1
96088.25		-0.00815					1.05801		1
96088.38						3.07767	1.05801	145	1
96088.5		-0.00815					1.05801		1
96088.63					-0.17587	2.63801	0.975572		1
96088.75		0.027495					0.975572		1
96088.88	-300.5					2.63801	0.975572		1
96089		-0.02138					0.975572		2
96089.13			141.569	267.142	-0.17587	2.63801	0.975572		2
96089.25		-0.02138					0.957252		2
96089.38						2.81387	0.957252	145	2
96089.5		-0.00815					0.957252		2
96089.63					0.351734	2.81387	0.957252		2
96089.75		-0.00815					0.957252		2
96089.88	-298					3.60528	1.05801		2
96090		0.005092					1.05801		3
96090.13			135.566	266.615	1.319	3.60528	1.05801		3
96090.25		0.005092					1.05801		3
96090.38						3.86908	1.14046	145	3
96090.5		-0.03768					1.14046		3
96090.63					-0.5276	3.86908	1.14046		3
96090.75		-0.03768					1.14046		3
96090.88	-305.5					3.86908	1.14046		3
96091		-0.13849					0.957252		4
96091.13			132.064	266.615	0.263801	2.98974	0.957252		4
96091.25		-0.13849					0.957252		4
96091.38						2.98974	0.957252	145	4
96091.5		-0.13849					0.957252		4
96091.63					-0.17587	1.75867	1.01679		4
96091.75		-0.06008					1.01679		4
96091.88	-302					1.75867	1.01679		4