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EXHIBIT NO. **13X - E**

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

Boeing 737 Quick Access Recorder Data Search Study

NATIONAL TRANSPORTATION SAFETY BOARD
Office of Research and Engineering
Washington, D.C.

November 9, 1995

Boeing 737 Quick Access Recorder Data Search Study

A. ACCIDENT DCA-94-MA-076

Location	:	Aliquippa, Pennsylvania
Date	:	September 8, 1994
Time	:	1904 Eastern Daylight Time
Aircraft	:	Boeing 737-300, N513AU

B. GROUP IDENTIFICATION

The QAR operational monitoring program was developed by the NTSB's Systems and Aircraft Performance Group Chairmen with assistance from personnel from the Air Accidents Investigation Branch (AAIB), Department of Transport, United Kingdom, and the Boeing Commercial Airplane Group.

C. SUMMARY

On September 8, 1994 at 1904 Eastern Daylight Time, USAir Flight 427, a Boeing 737-3B7, N513AU, crashed while maneuvering to land at Pittsburgh International Airport, Pittsburgh, Pennsylvania. The airplane was being operated on an instrument flight rules (IFR) flight plan under the provisions of Title 14, code of Federal Regulation (CFR), Part 121, on a regularly scheduled flight from Chicago O'Hare International Airport, Chicago, Illinois, to Pittsburgh. The airplane was destroyed by impact forces and fire near Aliquippa, Pennsylvania. All 132 persons on board the airplane were fatally injured.

D. DETAILS OF INVESTIGATION

1. Rationale for the Search

The investigation revealed that rudder movement may be a possible factor in the airplane's departure from controlled flight. Although USA427's FDR did not record rudder position (nor was it required), a kinematic study of the FDR data indicated that derived yaw rates were likely caused by rudder movement.

Assessment of rudder system operation is difficult without recorded rudder and rudder pedal data. The accident airplane did not record, nor was required to record, either rudder, rudder pedal, and lateral acceleration data. As a result of

this lack of data, the National Transportation Safety Board, along with several parties to the investigation, entered into a contract with a European airline and one of its sub-contractors, to study Quick Access Recorder (QAR) data taken from the airlines' 737-400 fleet. The airplanes involved record rudder and rudder pedal position. The program will monitor rudder usage and search for two exceedance events.

The program to monitor operational data from the 737-400s began October 15, and will continue for approximately six months.

2. Objectives of the Data Search

The identified objectives of the QAR data search program are the following:

A) Monitor practical rudder operation;
B) Monitor practical rudder pedal operation;
C) Monitor practical yaw damper operation;
D) Identify and collect data from any rudder or Y/D "events", to be added to the NTSB database of 737 incidents;
E) Monitor amount of rudder use and movement during flight operation;
F) Check reliability of recording sensors - QAR vs. FDR values;
G) Gain experience with airlines' flight monitoring or "trend analysis" programs.

3. Search Requirements

The identified search requirements for the QAR data study are as follows:

A) Sufficiently high-time 737's (15,000 - 20,000 flight hours);
B) Easily written and implemented event logic code;
C) Events are easily identified;
D) Related QAR/FDR parameter data are able to be subsequently dumped;
E) Event data can be output in a usable format on a usable medium;
F) Rudder and rudder pedal data are recorded and correctly converted;
G) "Events" due to faulty or out-of-sync data easily analyzed and identified as false events;
H) Able to correlate events back to specific flight, trip data, airplane, and the have the ability to acquire flight crew input as to the nature of the event, without loss of airline anonymity;
I) Listing of all QAR/FDR parameters and sampling rates;
J) Definition of normal operation of rudder system via plot of rudder movement versus pedal movement, and accounting for yaw damper activation.

4. Discussion of Program

To better understand the dynamics of the rudder system, and to understand how the rudder system is used in flight, the NTSB sought data from related B-737 investigations. In addition to the accident FDR, the NTSB read out several recorders from B-737 "rudder incidents" that have occurred since the accident. Though several of the airplanes involved recorded rudder or rudder pedal information, none recorded rudder and pedal information. The lack of recorded rudder and pedal position on these FDRs made determination of rudder movement, and the initiating source of the movement, imprecise.

Within the U.S-registered B-737 fleet, rudder and pedal position are recorded on few 737s; 737s built after May 26, 1989 are required to record rudder or rudder pedal position, but not both parameters.

Some B-737s within the European fleet, however, record rudder and rudder pedal position. On these airplanes, data is often recorded via Quick-Access Recorders (QAR), which allow much less data processing time than FDRs. In fact, several European carriers have dedicated flight monitoring programs that process, search, and identify operational data for event identification, system monitoring, and trend analysis. The AAIB has assisted the Safety Board by polling several European carriers to determine their willingness to assist the investigation by collecting and searching QAR data for rudder events. Two airlines offered assistance to the investigation. Both airlines have established programs for collecting data. The NTSB contracted a data search with one of these airlines.

The European airline the NTSB contracted with has 25 B-737-400's within its fleet, all about four years old. QAR's on these airplanes record rudder and rudder pedal position twice per second. For the duration of the data search program, the airline will increase the QAR rudder pedal sampling rate to four times per second. Yaw damper authority is ±3 degrees on the airplanes.

As part of the program, the airline will monitor QAR data retrieved from each 737-400 on a flight-by-flight or daily basis. To accomplish this, the airline utilizes a ground-based computer fleet monitoring program which reads, converts, analyzes, and collates the QAR data. In addition, the program will search for rudder exceedances (or "events"). To identify the exceedances, a series of event logic was developed (see section H, "Program Histograms and Events", number 2) by NTSB, AAIB, and Boeing. The event logic sets parameter guidelines and conditions which, if exceeded, constitutes an event. The event logic was converted into software routines and entered into the fleet monitoring software by an airline sub-contractor. The airline and sub-contracting company have charged a fee for the process of adding the event logic to the current fleet monitoring software. The fee was shared by several of the parties to the investigation.

The results from the QAR monitoring program are a series of data sets which meet the established criteria. Staff from the NTSB, AAIB, and the parties to the investigation will study the data to determine system anomalies (if any) and

gain knowledge about rudder package operation.

E. PROGRAM MILESTONES

1) Establish contact with two potential QAR program airlines: March, 1995.
2) Receive plot from Boeing of typical 737 rudder vs. rudder pedal movement: April, 1995
3) Establish logic to determine rudder events and identify wanted data: teleconference with staff from AAIB and parties to the investigation for consensus: April through June, 1995.
4) Meet with contracting airlines staff to coordinate and initiate program: End of July, 1995.
5) Event logic software implemented for test program: Mid-August, 1995.
6) Request for additional control wheel histogram and event logic: September, 1995.
7) Commence collecting and monitoring data: Mid-October, 1995.

F. PROGRAM HISTOGRAMS AND EVENTS

The QAR data search program consists of two phases: 1) collecting and tabulating rudder and yaw damper activity in histograms, and 2) monitoring data against pre-selected "event" or exceedance limits.

1. Rudder and Yaw Damper Activity Histograms

Data distribution tables are generated by accumulating counts of parameters in the following manner:

A) Rudder Position Histograms

Good samples of rudder position are distributed into a table of windows of consecutive data ranges. The window size is 1° and centered about 0.0° (i.e. -0.49° to +0.49°, etc.), to ±26.49°, the operational range of the rudder.

B) Yaw Damper Activity Histograms

Yaw damper input is distributed into tables by the difference between each good sample of rudder position and the rudder position commanded by each good associated sample of rudder pedal position. The difference between the commanded and actual rudder position is accumulated into windows of consecutive incremental ranges of 0.20°, centered about 0.0° (i.e., -0.19 to 0.0, 0.0 to 0.19, etc.). Since rudder pedal is recorded four times per second and rudder twice, the first and third rudder pedal samples

are compare to the first and second rudder samples, respectively each second.

The resultant data tables were provided to the NTSB in histograms based on the following phases of flight:

A) Takeoff and initial climb through 5,000 Feet;
B) Climb, cruise, and descent to 5,000 Feet;
C) Final descent from 5,000 Feet until landing;

Note: Data is used only when the airplane is flying and above an altitude of 50 feet above ground level.

2. Operational Events

For this portion of the program, data are monitored for the following prescribed exceedances:

A) Lateral Acceleration Event: Lateral acceleration data are monitored for exceedances of greater than ±0.10 G's for 2 successive samples in good data. Lateral acceleration is recorded 4 times per second.

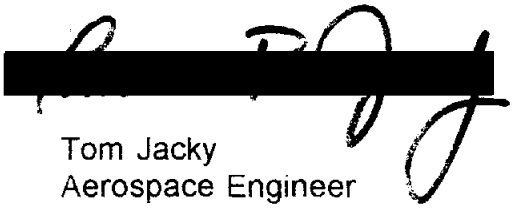
B) Rudder Disagreement Event: Rudder and rudder pedal data are monitored for surface position disagreements greater than 3.0°. Since rudder is recorded twice per second and rudder pedal 4 times per second, the first and third rudder pedal samples are compared with the respective rudder surface sample each second.

Updates of program process are to be provided on a regular basis. The first program update was provided to the NTSB on October 31, 1995. The results of the update are included in the Attachments to this report. A listing of the flagged events is not included in this report, and will be added to the docket in another exhibit.

3. Future Program Additions

The airline sub-contractor is in the process of implementing an additional histogram and event logic sub-routine to the fleet monitoring program. After contracting for the histograms and events detailed above, the parties asked the airline and sub-contractor for a control wheel histogram and a rudder/control wheel cross-control event. The control wheel histogram will tabulate wheel position using incremental value ranges, and the rudder/control wheel event or "excess rudder" event will seek instances of prolonged rudder input against an opposite wheel input. At the time this report was written, the additional histogram and event had not been entered into the functional fleet monitoring program.

Addendums to this report will be written as updates to the program are received. In addition, after the program has completed, a final summary will be written.



Tom Jacky
Aerospace Engineer

Attachments

1. Rudder Histogram Data Table and Plots from October 31, 1995 Program Update
2. Yaw Damper Activity Histogram Data Table and Plots from October 31, 1995 Program Update

ATTACHMENT 1

Rudder Histogram Data Table and Plots
From October 31, 1995 Program Update

Rudder Histogram Data Table

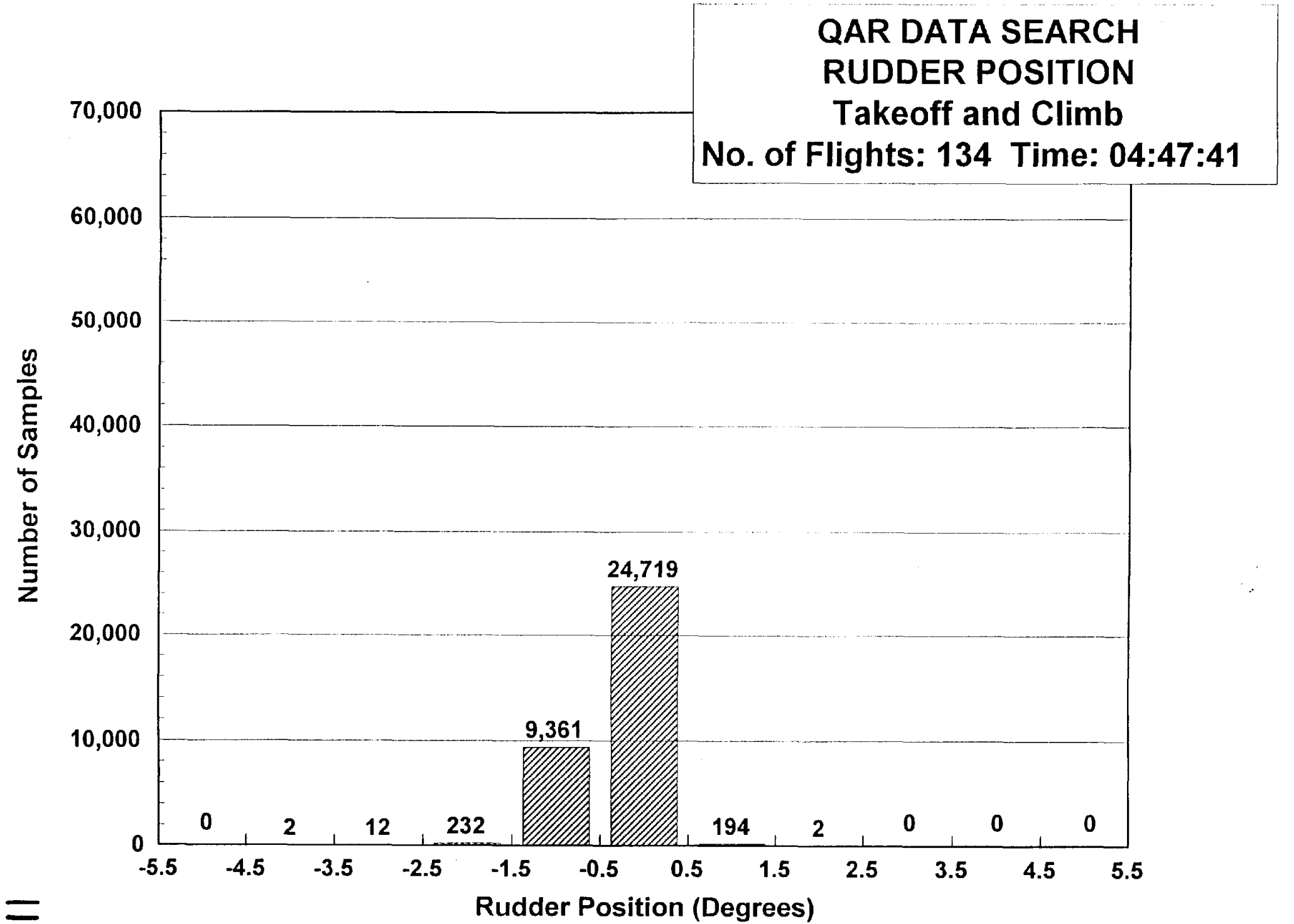
QAR DATA SEARCH No of Flights: 134			
RUDDER POSITION	Takeoff and Climb (Phase A)	Climb, Cruise and Descent (Phase B)	Approach and Landing (Phase C)
(Degrees)	**Time in Phase: 04:47:41**	**Time in Phase: 155:19:20**	**Time in Phase: 14:26:59**
-5.49 to -4.50	0	0	0
-4.49 to -3.50	2	0	5
-3.49 to -2.50	12	0	52
-2.49 to -1.50	232	198	1,343
-1.49 to -0.50	9,361	500,004	34,890
-0.49 to 0.50	24,719	618,098	67,038
0.50 to 1.49	194	19	657
1.50 to 2.49	2	1	44
2.50 to 3.49	0	0	5
3.50 to 4.49	0	0	4
4.50 to 5.49	0	0	0
Total Number of Good Samples in Phase	34,522	1,118,320	104,038

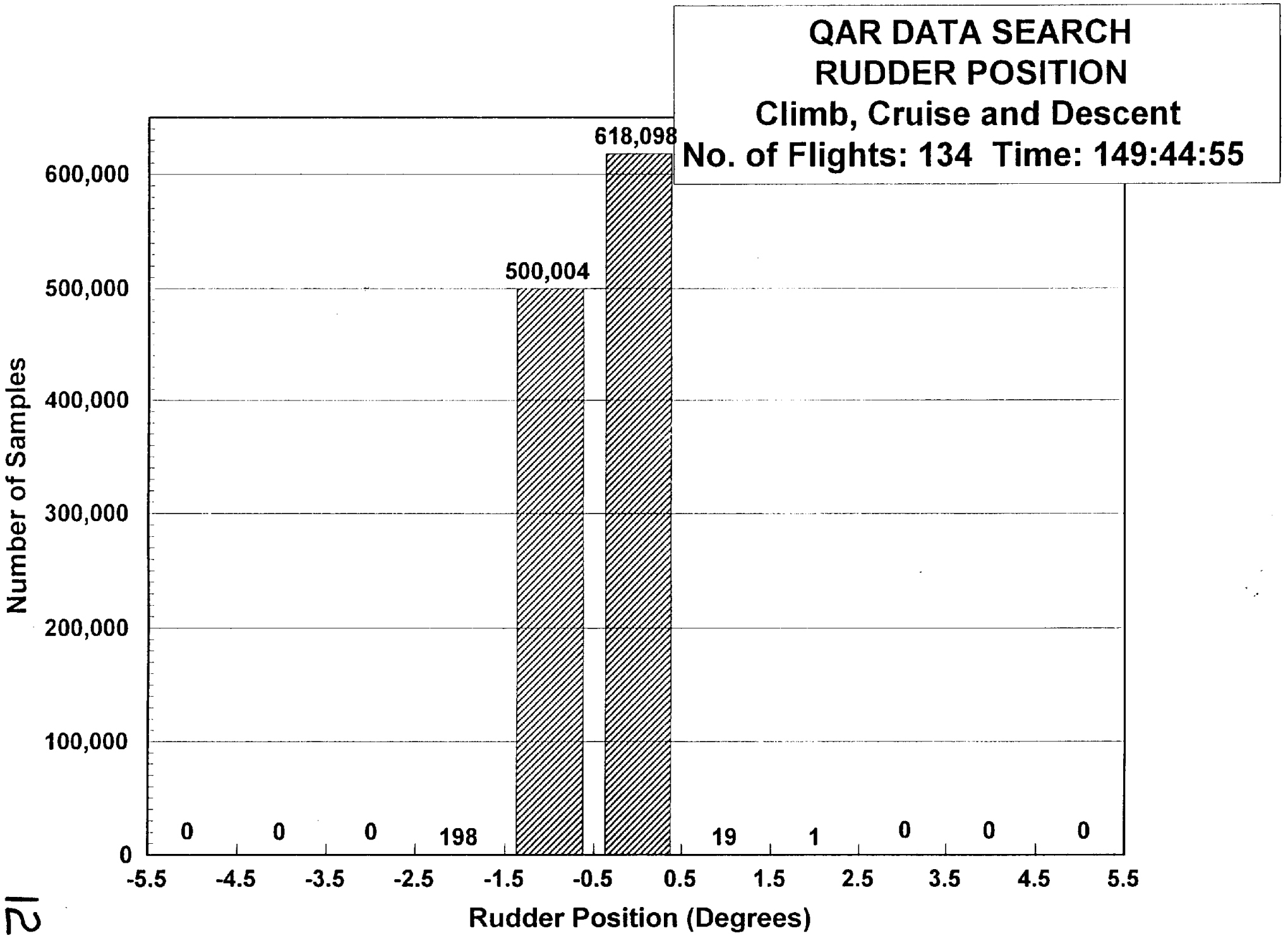
Note: Rudder Position is Sampled Twice per Second.

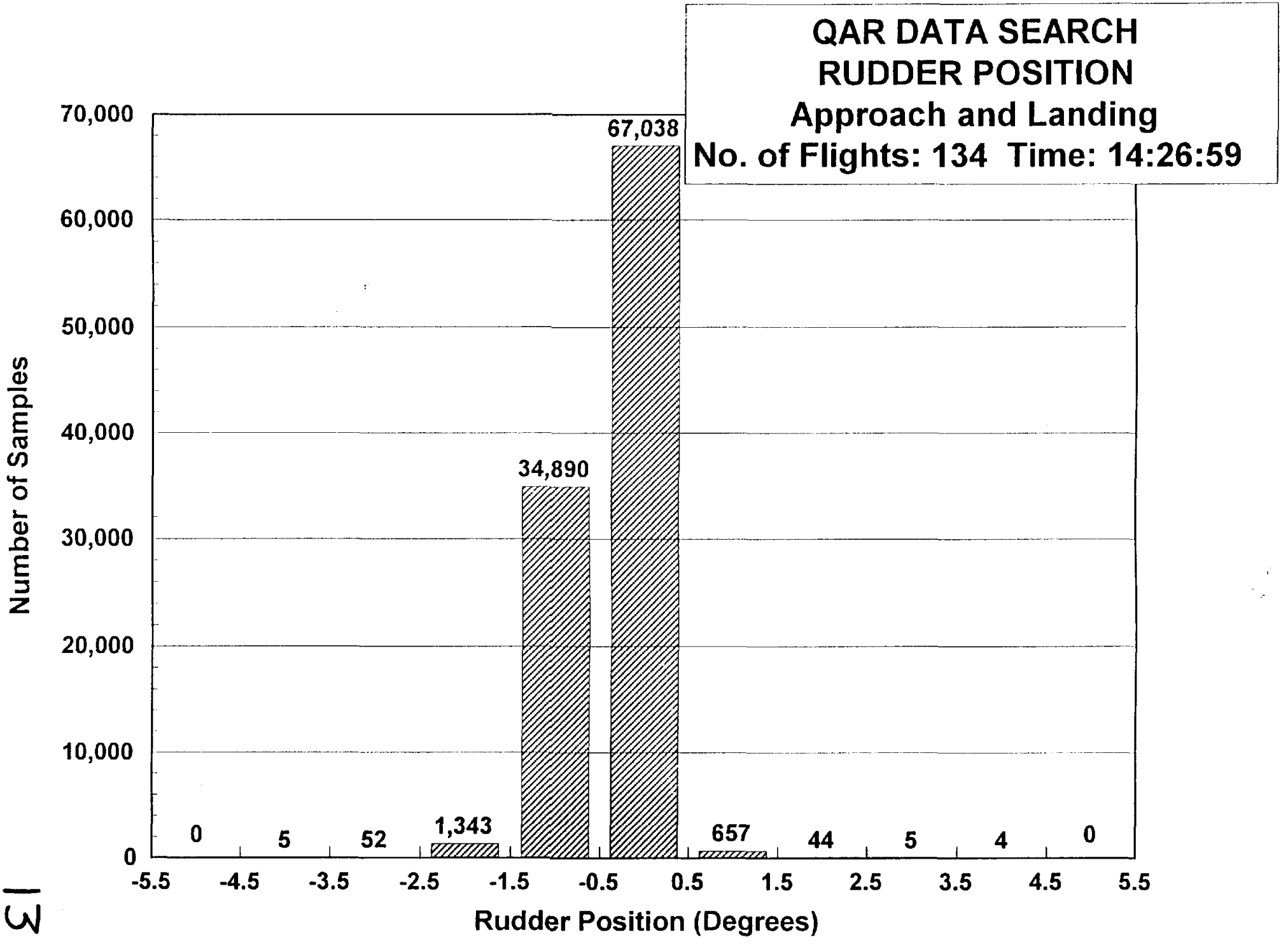
NOTE: VALUES IN ALL SAMPLE RANGES NOT SHOWN ARE ZERO.

Rudder Histogram Data Plots

Flight Phase A
Flight Phase B
Flight Phase C


QAR DATA SEARCH
RUDDER POSITION
Takeoff and Climb
No. of Flights: 134 Time: 04:47:41
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Number of Samples
0
2
12
232
9,361
24,719
194
2
0
0
0
-5.5
-4.5
-3.5
-2.5
-1.5
-0.5
0.5
1.5
2.5
3.5
4.5
5.5
Rudder Position (Degrees)


QAR DATA SEARCH
RUDDER POSITION
Climb, Cruise and Descent
No. of Flights: 134 Time: 149:44:55
618,098
500,004
600,000
500,000
400,000
300,000
200,000
100,000
0
Number of Samples
0
0
0
198
19
1
0
0
0
-5.5
-4.5
-3.5
-2.5
-1.5
-0.5
0.5
1.5
2.5
3.5
4.5
5.5
Rudder Position (Degrees)


QAR DATA SEARCH
RUDDER POSITION
Approach and Landing
No. of Flights: 134 Time: 14:26:59
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Number of Samples
67,038
34,890
0
5
52
1,343
657
44
5
4
0
-5.5
-4.5
-3.5
-2.5
-1.5
-0.5
0.5
1.5
2.5
3.5
4.5
5.5
Rudder Position (Degrees)

ATTACHMENT 2

Yaw Damper Activity Histogram Data Table and Plots from October 31, 1995 Program Update

Yaw Damper Activity Histogram Data Table

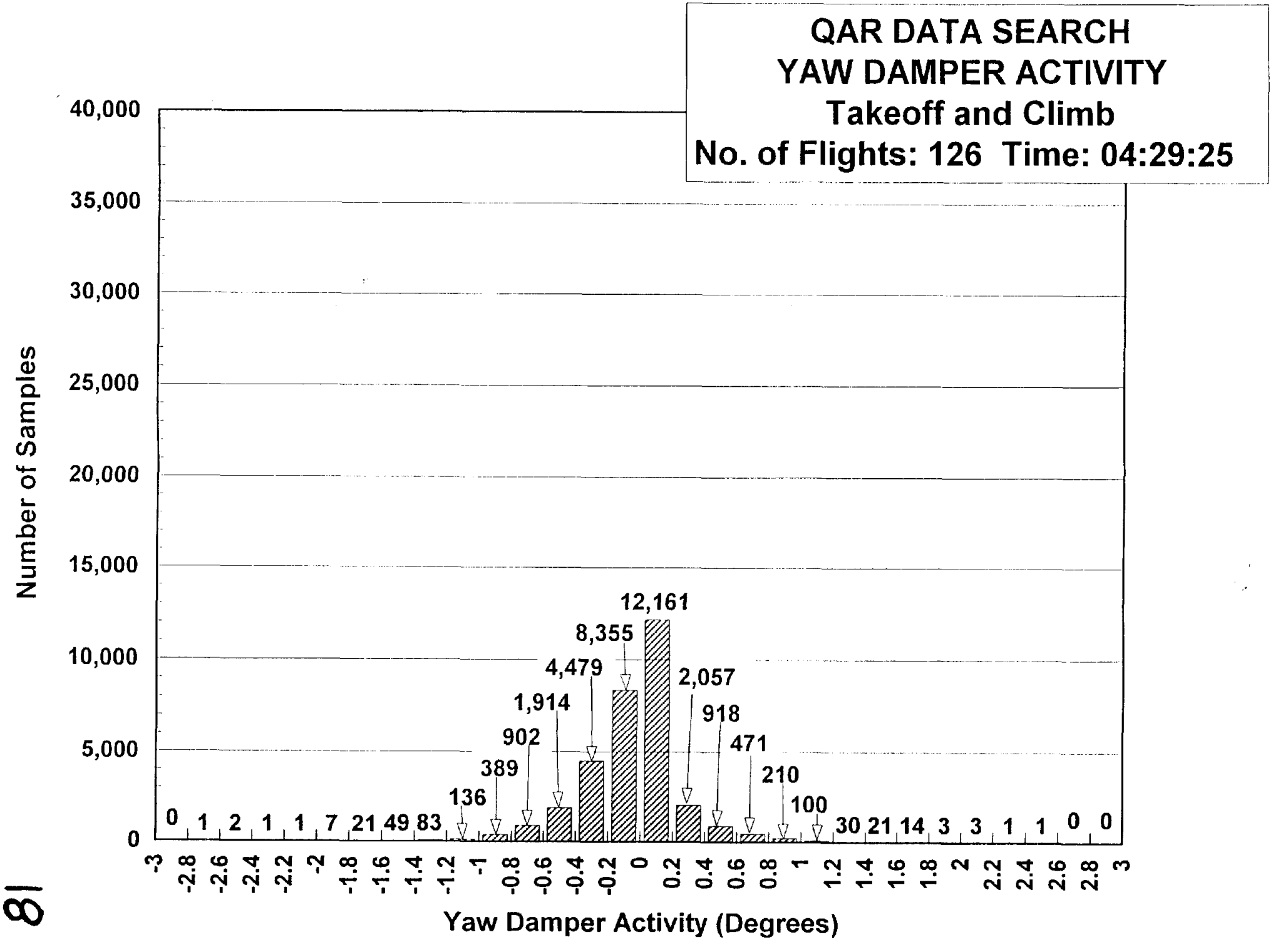
QAR DATA SEARCH Number of Flights: 126			
YAW ACTIVITY	Takeoff and Climb (Phase A)	Climb, Cruise and Descent (Phase B)	Approach and Landing (Phase C)
(Degrees)	**Time in Phase: 04:29:25**	**Time in Phase: 149:44:55**	**Time in Phase: 13:38:18**
-2.99 to -2.80	0	0	5
-2.79 to -2.60	1	0	5
-2.59 to -2.40	2	0	6
-2.39 to -2.20	1	0	22
-2.19 to -2.00	1	2	18
-1.99 to -1.80	7	3	45
-1.79 to -1.60	21	9	107
-1.59 to -1.40	49	14	224
-1.39 to -1.20	83	44	465
-1.19 to -1.00	136	218	792
-0.99 to -0.80	389	1,059	1,553
-0.79 to -0.60	902	15,630	2,969
-0.59 to -0.40	1,914	177,220	5,969
-0.39 to -0.20	4,479	454,452	13,109
-0.19 to 0.00	8,355	332,094	27,051
0.00 to 0.19	12,161	93,601	34,007
0.20 to 0.39	2,057	2,848	5,538
0.40 to 0.59	918	696	2,944
0.60 to 0.79	471	203	1,661
0.80 to 0.99	210	68	827
1.00 to 1.19	100	21	443
1.20 to 1.39	30	3	200
1.40 to 1.59	21	4	103
1.60 to 1.79	14	0	53
1.80 to 1.99	3	0	34
2.00 to 2.19	3	0	20
2.20 to 2.39	1	0	14
2.40 to 2.59	1	0	7
2.60 to 2.79	0	0	4
2.80 to 2.99	0	0	1
Total Number of Good Samples in Phase	**32,330**	**1,078,189**	**98,196**

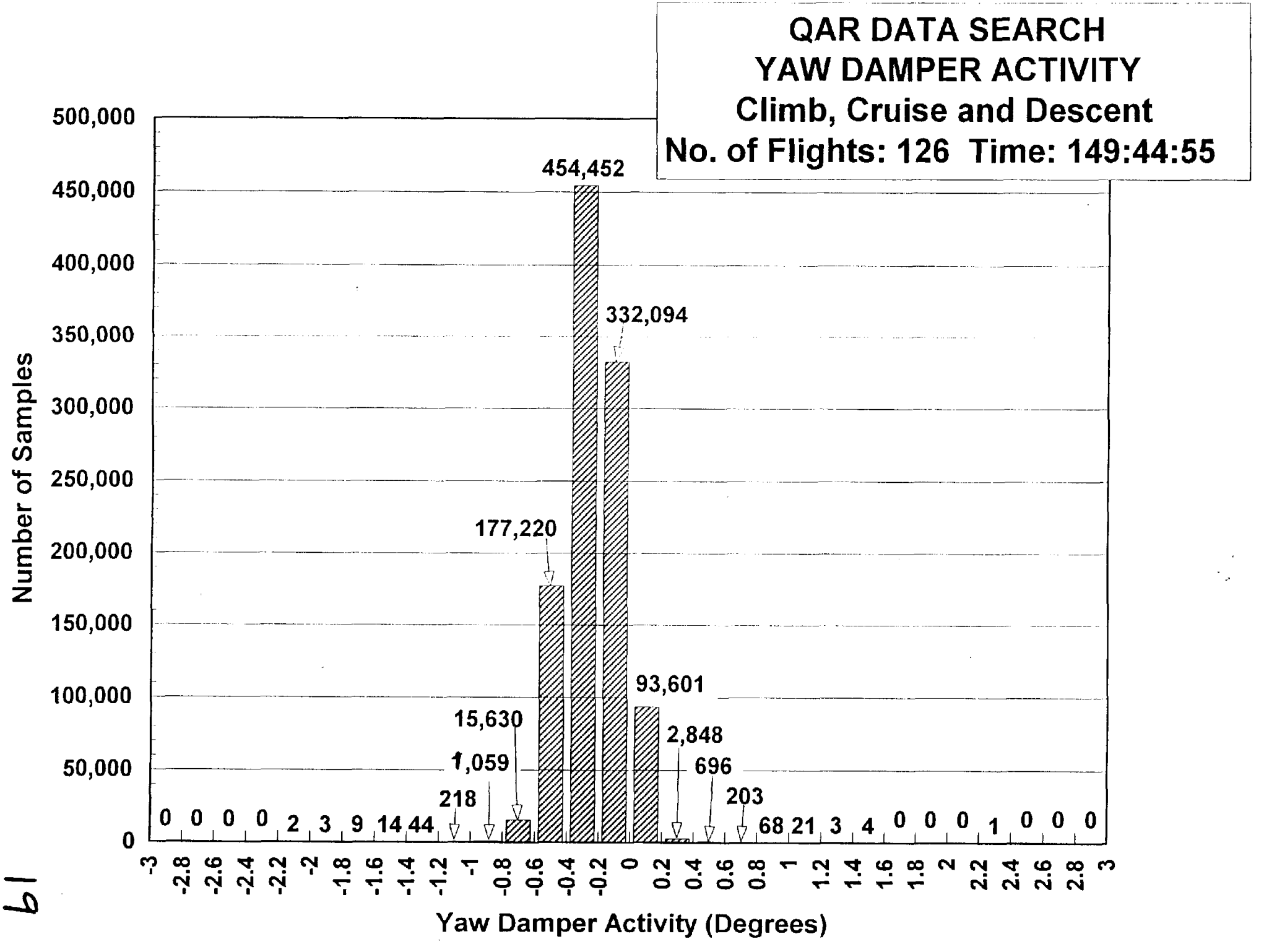
Note: Yaw Damper Activity is Sampled and Calculated Twice per Second.

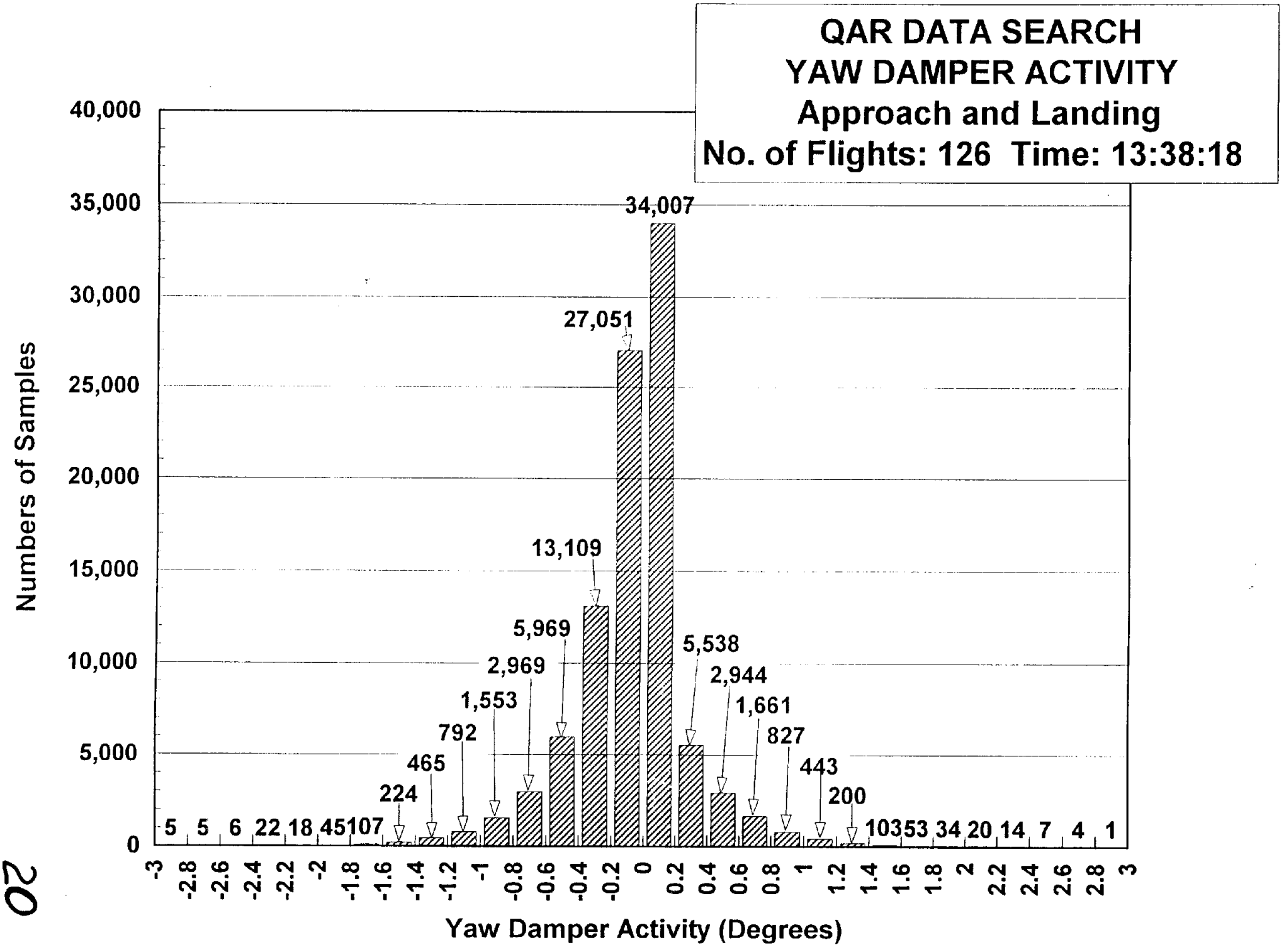
ALL SAMPLE VALUES IN RANGES NOT SHOWN IN THIS SPREADSHEET ARE ZERO.

Yaw Damper Activity Histogram Data Plots

Flight Phase A
Flight Phase B
Flight Phase C


QAR DATA SEARCH
YAW DAMPER ACTIVITY
Takeoff and Climb
No. of Flights: 126 Time: 04:29:25
Number of Samples
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
0 1 2 1 1 7 21 49 83 136 389 902 1,914 4,479 8,355 12,161 2,057 918 471 210 100 30 21 14 3 3 1 1 0 0
-3 -2.8 -2.6 -2.4 -2.2 -2 -1.8 -1.6 -1.4 -1.2 -1 -0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3
Yaw Damper Activity (Degrees)


QAR DATA SEARCH
YAW DAMPER ACTIVITY
Climb, Cruise and Descent
No. of Flights: 126 Time: 149:44:55
Number of Samples
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
454,452
332,094
177,220
93,601
15,630
2,848
1,059
696
218
203
0 0 0 0 2 3 9 14 44 68 21 3 4 0 0 0 1 0 0 0
-3 -2.8 -2.6 -2.4 -2.2 -2 -1.8 -1.6 -1.4 -1.2 -1 -0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3
Yaw Damper Activity (Degrees)


QAR DATA SEARCH
YAW DAMPER ACTIVITY
Approach and Landing
No. of Flights: 126 Time: 13:38:18
Numbers of Samples
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
34,007
27,051
13,109
5,969
5,538
2,969
2,944
1,661
1,553
827
792
465
443
224
200
5 5 6 22 18 45 107 10 3 53 34 20 14 7 4 1
-3 -2.8 -2.6 -2.4 -2.2 -2 -1.8 -1.6 -1.4 -1.2 -1 -0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3
Yaw Damper Activity (Degrees)