NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594

August 3, 2004

Human Performance

GROUP CHAIRMAN'S FACTUAL REPORT
ADDENDUM 3

A. ACCIDENT

Operator: American Airlines (flight 587)
Location: Belle Harbor, New York
Date: November 12, 2001
Time: 0916 eastern standard time
Aircraft: Airbus A300-600, N14053
NTSB Number: DCA02MA001

B. HUMAN PERFORMANCE GROUP CHAIRMAN:

Malcolm Brenner, Ph.D.
National Resource Specialist -- Human Performance
National Transportation Safety Board

C. ACCIDENT SUMMARY

On November 12, 2001, about 0916 eastern standard time, American Airlines flight 587, an Airbus A300-600, was destroyed when it crashed into a residential area of Belle Harbor, New York, shortly after takeoff from the John F. Kennedy International Airport (JFK), Jamaica, New York. Two pilots, 7 flight attendants, 251 passengers, and 5 persons on the ground were fatally injured. Visual meteorological conditions prevailed and an instrument flight rules flight plan had been filed for the flight destined for Santo Domingo, Dominican Republic. The scheduled passenger flight was conducted under Title 14 Code of Federal Regulations (CFR) Part 121.

D. DETAILS OF THE INVESTIGATION

This report summarizes the factual material collected since Addendum 2 to the Human Performance Group Chairman's Factual Report was completed on December 23, 2003.

D.1 Pedal sensitivity comparisons

To support the Human Performance Group investigation, the Performance Group Chairman (O'Callaghan) prepared calculations related to the sensitivity of rudder pedal inputs as they would be experienced by pilots through resulting cockpit motions.

For the calculations, "sensitivity" was defined as the magnitude of airplane motion in response to a given amount of rudder pedal force above the breakout force. A simple measure of airplane motion was defined as the lateral acceleration in the cockpit resulting from the yaw moment produced by the rudder, starting from straight and level flight. Using the rudder effectiveness defined in the A300-600 simulator database, sensitivity was calculated for each of the two rudder pedal designs available on the A300 airplane – the variable ratio design of the B2B4 model and the variable stop design of the 600 model. Because the rudder(yaw)-induced lateral acceleration at the pilot station for a given airplane configuration depends upon the amount of rudder deflection and the flight condition (dynamic pressure), since the amount of rudder deflection depends on the ratio of rudder deflection to pedal input, and since the amount of pedal input depends on the pedal force applied by the pilot and the characteristics of the pedal feel system, it follows that the difference in pedal sensitivity for different rudder system designs on the same airplane depends upon two design variables: the ratio of rudder deflection to pedal input, and the pedal force characteristics.[1]

Figure 1 illustrates the calculated pedal sensitivities as determined for each of the two A300 rudder designs. With increasing airspeed, the pedal sensitivity for the variable ratio design of the A300–B2B4 remained relatively constant with airspeed while the variable-stop design increased.

D.2 Service history of significant tail load events

An earlier Structures Group report[2] summarized data from Airbus Industrie of in-flight events in the service history of A300/A310 airplanes involving high structural loads on the aircraft tail. With the assistance of Airbus Industrie, the scope of these data were expanded to reflect the entire Airbus product line and to highlight events that might involve pilot/rudder pedal interaction. Events for which the load on the tail (either recorded or calculated) exceeded a value of 1.0 limit load were examined.

Table 1 displays the events by aircraft type along with worldwide flight hours for each type reported to Airbus (as of February, 2004). Table 2 summarizes additional information provided by Airbus, including a general description of the operator,[3] a summary of whether or not the pilot made rudder inputs during the event ("rudder use"), the airspeed at which the event occurred, and the recorded or calculated tail load.[4] The present accident is shown in bold letters. According to an Airbus representative, these data were compiled from an electronic library of flight data recorder records and other investigative material maintained by the company for internal product safety investigation and represent either recorded or estimated information. The representative stated that Airbus field representatives working with major Airbus operators would advise the company daily of all events of safety interest, and a weekly review conducted by a screening committee would identify the most significant events for which Airbus would request data from the operator to conduct an internal investigation. The electronic library therefore contained data from all company-known significant events experienced in worldwide line operations.

[1] Values for these variables are provided in the Human Performance Group Chairman's Factual Report, Addendum 1, p. 31.
[2] Structures Group Factual Report, Exhibit 7Q. Airbus Vertical Tail High Loads for In Service Events, Docket SA-522.
[3] American Airlines is identified by name only because of its involvement in the current accident which made it impossible to safeguard its anonymity.
[4] These determination of whether the pilot made rudder input was based on FDR

As shown in Table 1, there were 9 high tail load events and these involved the A310, A300-600, and A340 airplanes. According to Table 2, 6 of these events involved pilot input on the rudder.[5]

According to a representative of the Boeing Commercial Airplane Company ("Boeing"), the company maintains records of significant in-flight events as reported by the airlines involving Boeing-designed and McDonnell Douglas-designed airplanes. According to the representative, the company is not aware of any events involving vertical tail loads from in-flight maneuver or gust greater than limit load for any of the company's products.

D.3 Lateral forces portrayed on the American Airlines training simulator

As noted in an earlier report,[6] the A-310/300 training simulator at the American Airlines Training Academy provided a calculated output for instantaneous lateral acceleration ("y-acceleration") that was observed to vary as a result of different recovery strategies used on the AAMP excessive bank angle recovery exercise. The recorded data show that during these recoveries, an A300-600 airplane would have been subjected to lateral load factors that averaged from 0.283 to .474 g depending on the strategy.

In response to a request from the Safety Board, American Airlines provided data in the attached Table 3 showing the maximum simulator motion parameters portrayed on this simulator.

Submitted By:

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[5] For additional information on cited accidents involving rudder use, see National Transportation Safety Board, Accident involving American Airlines Flight 903 near West Palm Beach, Florida on May 12, 1997, NTSB #DCA97MA049; German Federal Office of Aviation Air Accident Investigation Department, Report on the investigation of the abnormal behavior of an Airbus A310-304 aircraft on 11.02.1991 at Moscow, Ref.: 6 X 002-0/91; Bureau Enquetes-Accidents (BEA), Report on the incident on 24 September 1994 during approach to Orly (94) to the Airbus A 310 registered YR-LCA operated by Tarom, BEA Report YR-A940924A.

[6] Human Performance Group Study Report, American Airlines Simulator Exercise, September 26, 2003, pages 11-13.

Table 1. Airbus service history of high tail load events (tail load > 1.0 limit load).

Model	number of events exceeding limit load	number of events involving pilot input	Flight hours of world fleet
A-300-B2/B4	0	0	9,765,529
A310	3	3	9,552,784
A300-600	4	3	6,694,865
A320	0	0	32,720,365
A330	0	0	4,210,781
A340	2	0	6,059,301

Table 2. Airbus descriptive data for nine high load events.

Airline	date	descriptor	rudder use	airspeed (KIAS)	tail load (Gs)
A310					
A	2/91	stall/loss of control	yes	50-300	1.55
B	9/94	stall/loss of control	yes	190-225	1.12
C	11/99	runaway trim	yes	275	1.06
A300-600					
D	5/89	rudder jerk in climb	yes	250	1.11
D	5/97	stall/loss of control	yes	190-230	1.53
D	3/99	maintenance	no	180-190	1.16
D	**11/01**	**turbulence**	**yes**	**250**	**1.83-2.14***
A340					
E	6/00	turbulence	no	330	1.04
F	11/01	loss of ADC	no	335	1.17

Airline Code:

A = Western European passenger charter airline
B = Eastern European scheduled passenger airline
C = Western European scheduled passenger airline
D = American Airlines
E = Western European scheduled passenger airline
F = Asian scheduled passenger airline

*This range of estimates for tail load was developed in the current investigation. See Addendum 2 to the Aircraft Performance Group Chairman's Report.

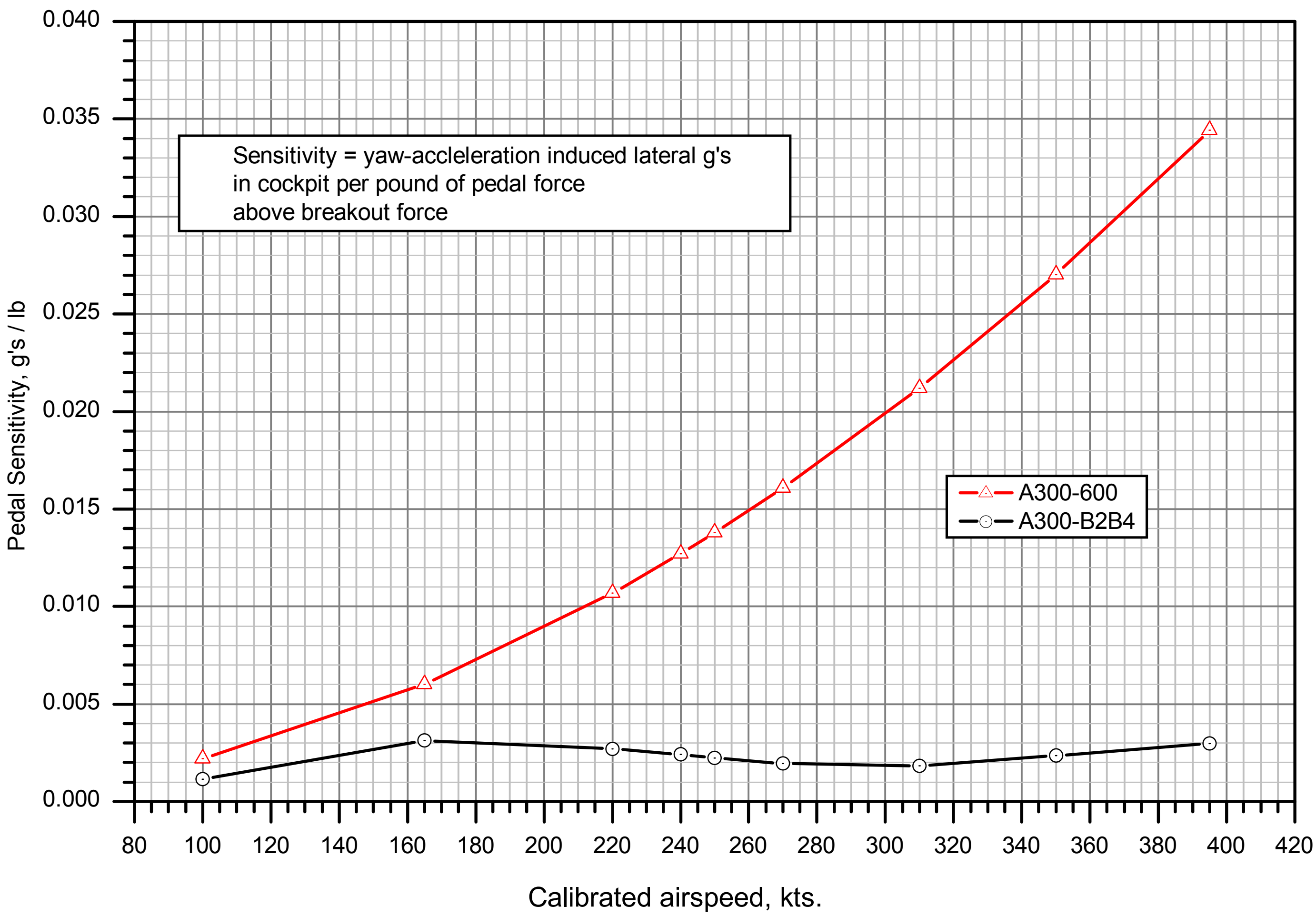

Figure 1. Comparison of A300-600 and A300-B2B4 pedal sensitivities.

Table 3. Summary of maximum simulator motion parameters available on the A300/310 moving –based simulator at the American Airlines Flight Academy on which AAMP recurrent training exercises were presented.

1. Pitch — +36 deg , -31 deg
2. Pitch Velocity — +24 , -20 deg/sec
3. Pitch Acceleration — $\pm$100 deg / sec^2
4. Roll Angle — $\pm$28 deg
5. Roll Velocity — $\pm$22 deg / sec
6. Roll Acceleration — $\pm$100 deg / sec^2
7. Yaw Angle — $\pm$32 deg
8. Yaw Velocity — $\pm$25 deg / sec
9. Yaw Acceleration — $\pm$100 deg / sec^2
10. Heave Displacement — 70 inches total
11. Heave Velocity — $\pm$2 ft/sec
12. Heave Acceleration — $\pm$25.6 ft/sec^2 ($\pm$0.8g)
13. Lateral Displacement — $\pm$45 inches with zero yaw. Thereafter the lateral displacement is proportional to the introduction of yaw with a maximum of 6 inches displacement possible with 7 degrees of yaw.
14. Lateral Velocity — $\pm$2 ft/sec
15. Lateral Acceleration — $\pm$22.4 ft/sec^2 ($\pm$0.7g)
16. Longitudinal Displacement — $\pm$53 inches
17. Longitudinal Velocity — $\pm$2 ft/sec
18. Longitudinal Acceleration — $\pm$22.4 ft/sec^2 ($\pm$0.7g)