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April 20 , 1995
~~B-U01B-15232-ASI~~

Mr. John Clark
National Transportation Safety Board
490 L'Enfant Plaza SW
Washington, D.C. 20594

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Subject: USAir 737-300 N513AU Accident Near Pittsburgh 8 Sep 94

Reference: Your telephone conversation with J. Kerrigan, 3/30/95

Dear Mr. Clark:

During the reference phone call you requested that any further analysis or information available related to the possibility of an in-flight thrust reverser deployment during the USAir accident be provided to the NTSB. The following discussion is provided to satisfy that request. The analysis of the accident aircraft thrust reverser components that led to the original conclusion that the thrust reversers were not involved in the accident are not reiterated in this letter.

An evaluation of the USAir 427 accident Flight Data Recorder (FDR) has shown that yawing moment coefficient required to sustain the maneuver experienced during the accident sequence was on the order of $\Delta Cn = -0.055$. In order to determine if the thrust reversers could have sustained the accident sequence, the incremental thrust required can be calculated using the following equation:

$$\Delta Cn_{eng} = \Delta Cn = ((F_1-F_2)*y_{eng})/(q*S*b) \qquad \text{equation 1}$$

where

ΔCn_{eng} = yawing moment coefficient from differential thrust
F_1 = thrust from the left engine - lb
F_2 = thrust from the right engine - lb
y_{eng} = the effective engine moment arm - 16.14 ft
q = dynamic pressure - 122 lb/ft^2 (190 knots)
S = reference wing area - 980 ft^2
b = reference wing span - 93 ft

Then, rearranging equation 1

$(F_1-F_2) = \Delta Cn*q*S*b/y_{eng}$
$(F_1-F_2) = -0.055*122*980*93/16.14$
$(F_1-F_2) = -37{,}890$ lb

To produce a yawing moment to the left, the right engine must be in forward thrust and the left engine is in reverse. The CFM56 engine produces approximately 4,500 lb forward thrust at the FDR recorded N_1 of 66% and the maximum reverse thrust at 190 knots is approximately 8,769 lb. Summing these thrusts results in a maximum incremental thrust of

$$(F_1-F_2) = (-8769)-4500 = -13,269 \text{ lb}$$

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This is less than half the incremental thrust that would be required to produce the yawing moment required to sustain the accident maneuver. Furthermore, as the maneuver progressed, the FDR recorded N_1 for both engines reduced to idle levels which would reduce the incremental thrust to much smaller values both in forward and reverse. It should also be noted that if the reverser had deployed, the thrust control of the affected engine would have been mechanically driven to an idle thrust condition. The FDR data for N_1 do not indicate a decrease in thrust command for either engine at the time the maneuver begins. Neither does acoustical analysis of data from the Cockpit Voice Recorder (CVR) indicate a decrease in N_1 at the time the maneuver begins.

In-flight reverser test data was obtained during the certification of the 737-300. Buffet levels during these tests were reported by the flight test pilots to be significant. The attached figure shows the in-flight reverser flight test data obtained during the 1985 certification of the 737-300 compared to the load factor and airspeed traces from the USAir 427 FDR. The buffet levels shown in the figure for the in-flight reverser flight test are for a single engine at reverse idle. Data are shown at the flight test recorded sample rate of 200 samples per second and at a thinned rate of 8 samples per second to provide data which compares with the accident FDR sample rate. The flight conditions shown include the flap and airspeed of USAir flight 427, flaps 1 and 190 knots. Buffet levels for an engine operating at above idle reverse would be expected to be even higher.

The flight test pilots also report that the buffet levels due to a single thrust reverser being deployed at idle thrust are sufficient to rattle loose objects in the cockpit and that those noises would be apparent on the CVR. Such noise is not present on the accident CVR.

In summary, analysis of the effects of thrust reversers on the flight characteristics of the 737-300 at the flight conditions of the USAir flight 427 accident has shown that the yawing moment generated by full reverse thrust on the left engine and full forward thrust on the right engine is not sufficient to sustain the maneuver experienced by the accident aircraft. Furthermore, the thrust reverser system retards the throttle to idle if a reverser deploys in-flight, which would cause a reduction in recorded N_1 during the initiation of the

maneuver. This reduction in N_1 does not appear either in the FDR data or in acoustical analysis of CVR data.

Flight test data obtained during the certification of the 737-300 of a single engine in reverse idle shows significantly more aerodynamic buffet in the load factor trace than is evident in the FDR traces from the accident aircraft. This flight test also demonstrated that noises in the cabin associated with the buffet would have been apparent on the CVR.

If The Boeing Company can be of further service, please do not hesitate to call.

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Very truly yours,

FLIGHT TEST

[redacted]

For

John W. Purvis
Director, Air Safety Investigation
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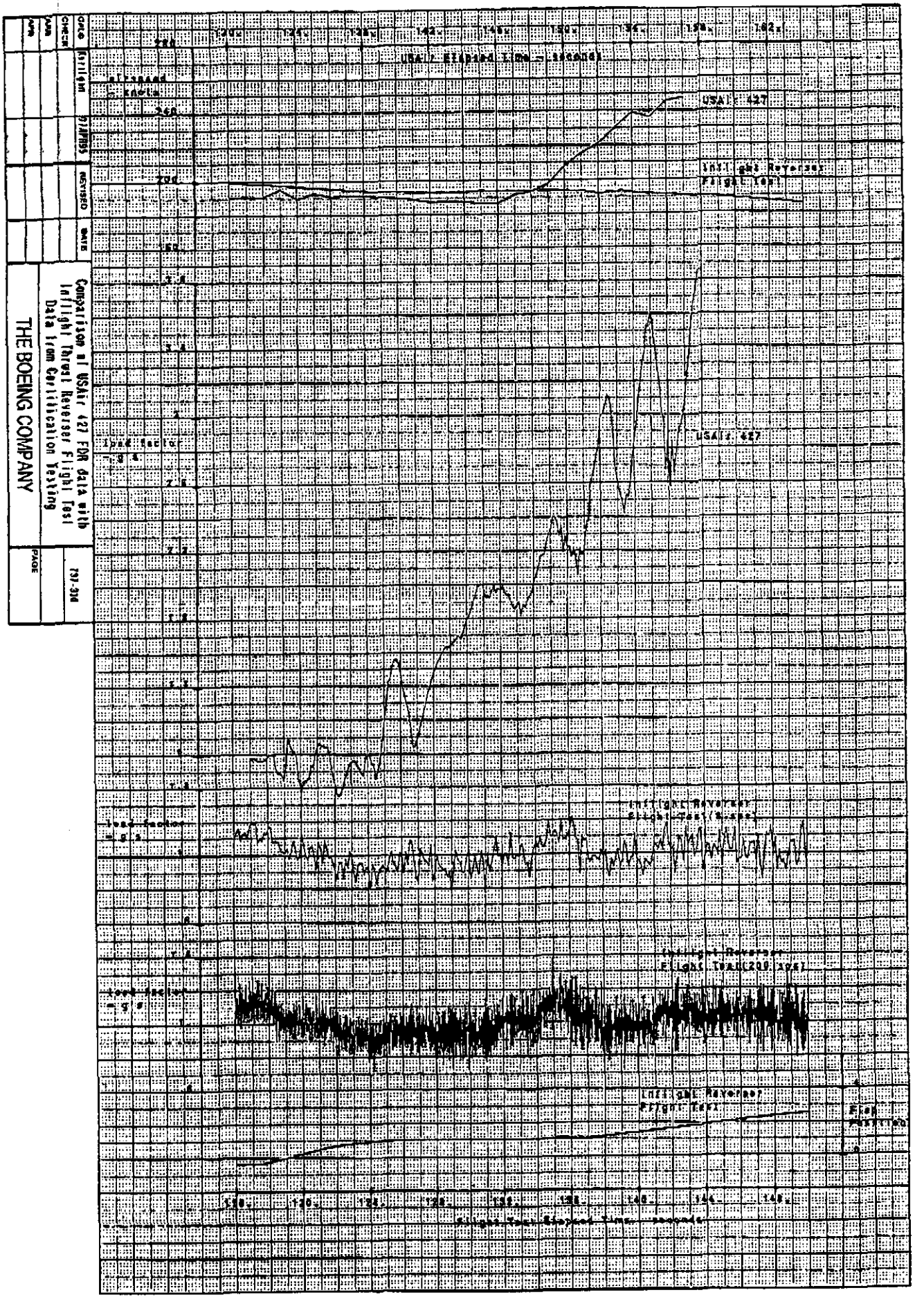
[redacted]

Enclosure: Plot "Comparison of USAir 427 FDR Data With Inflight Thrust Reverser Flight Test Data From Cerftification Testing"

cc: Tom Haueter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Comparison of USAir 427 FDR data with Inflight Thrust Reverser Flight Test Data from Certification Testing
737-3TH
USAir 427
Inflight Reverser Flight Test
Flight Test Elapsed Time - seconds