DOCKET No.: SA-521
EXHIBIT No. 13B

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C.

Emery 17 Airplane Performance Study – Addendum 1

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Washington, DC
February 4, 2002

Emery Flight 017 Airplane Performance Study
Addendum 1

Dennis Crider

A. ACCIDENT

Location:	Rancho Cordova, California
Date:	February 16, 2000
Time:	1951 Local Time
Aircraft:	Douglas DC-8-71, N8079 U
Operator:	Emery Worldwide Airlines, A CNF Company (FAR Part 121 Supplemental)
NTSB#:	DCA-00-MA-026

B. GROUP

Dave Yingling
Principal Engineer
The Boeing Company
3855 Lakewood Blvd MC D800-0035
Long Beach, CA 90846

Michael Huhn
Senior Staff Engineer
Air Line Pilots Association
535 Herndon Parkway
Herndon, VA 20170

Scott Odle
FAA - LAACO
Flight Test Branch, ANM-160L
3960 Paramount Blvd.
Lakewood, Ca 90712

Dennis Crider
Aerospace Engineer Performance
National Transportation Safety Board, RE-60
490 L'Enfant Plaza E, SW
Washington, DC 20594

C. SUMMARY

On February 16, 2000, at 1951 Pacific standard time, a Douglas DC-8-71F, N8079U, registered to and operated by Emery Worldwide Airlines as flight 17 for the 14 CFR Part 121 scheduled cargo service from Sacramento, California, to Dayton, Ohio, crashed shortly after takeoff from Mather Field, Rancho Cordova, California. Visual meteorological conditions prevailed and an instrument flight rules flight plan was filed. The airplane was destroyed by impact forces and a post-crash fire. The three flight crew members were fatally injured.

D. DETAILS OF INVESTIGATION

Purpose of Addendum

After the original report was placed on the docket, Boeing provided additional comments beyond those submitted when they reviewed the original draft. In response to these comments, this addendum contains additional work on center of gravity issues and investigates a possible anomaly on the approach into Dayton Ohio two landings previous to the accident.

Center of Gravity Issues

As outlined in the original report, the level of longitudinal stability is quantified through the derivative of pitching moment coefficient with respect to lift coefficient. From classic linear stability and control this is given by the following equation.

$$\delta C_m/\delta C_L = X_{cg} - N_0$$

Where X_{cg} and N_0 are the location of the center of gravity and the stick fixed neutral point as a percentage of mean aerodynamic chord (%mac). The Kinsurf program outputs the aerodynamic coefficient time histories required to produce the motion the FDR recorded. Similarly, the neutral point is known from Boeing design aerodynamic documents. Thus the center of gravity can be readily determined from the above equation.

The original report contains stability and center of gravity calculations using the unmodified aerodynamic coefficients as output by Kinsurf. In an effort to get a more accurate center of gravity, the original report also summed the effect of the elevator and the effect of dynamics in the aerodynamic coefficient build-up equations and removed these effects from the total airplane stability output by Kinsurf. The original report used the elevator as calculated by Kinsurf for this effort and reported the results duplicated in table 1. The segments referred to in this table are defined in the original report.

Segment	$\delta C_m/\delta C_L$	Center of Gravity
Segment 1	-0.243	24.2 % mac
Segment 2	-0.243 to -0.086	24.2 to -0.086 % mac
Segment 3	-0.243	24.2 % mac
Segment 4	-0.308	17.6 % mac
Segment 5	-0.223	26.2 % mac
Segment 6	-0.314	17.1 % mac

Table 1: Calculated Center of Gravity with corrected dCm/dCL using Kinsurf derived elevator

For this addendum, the effect of the elevator and the effect of dynamics in the aerodynamic coefficient build-up equations were summed and removed from the total airplane stability using the FDR elevator with the 11 deg offset discussed in the original report. The resulting stability is presented in figure 1 for the six flight segments.

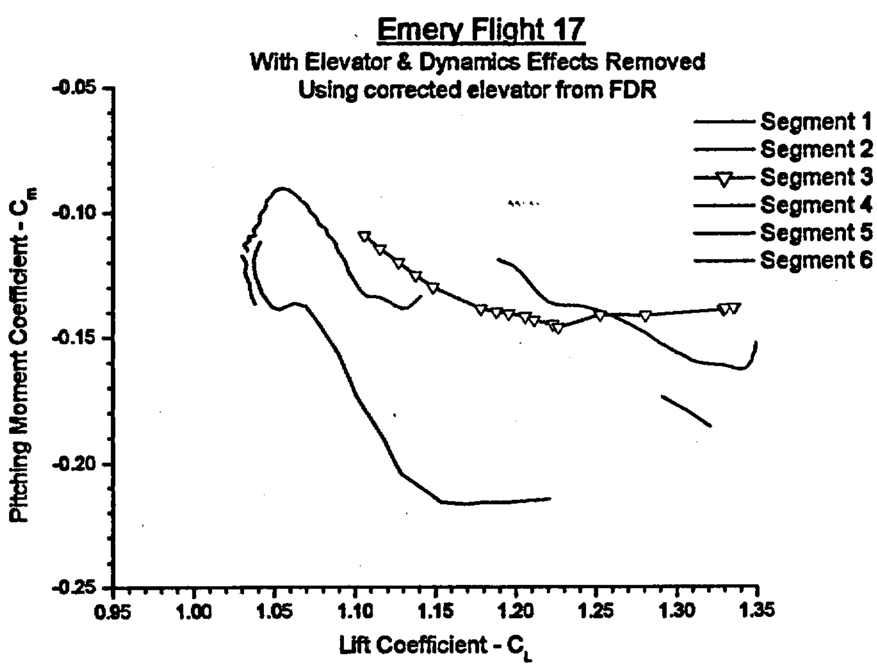

Figure 1: Corrected Cm vs. CL using FDR elevator

Using the 48.5% mac neutral point and the $\delta C_m/\delta C_L$ slopes obtained from figure 1, the center of gravity based on the stability with offset FDR elevator and dynamic effects removed is summarized in table 2.

Segment	$\delta C_m/\delta C_L$	Center of Gravity
Segment 1	-0.277 to -0.206	20.8 to 27.9 % mac
Segment 2	-0.667	-18.2 % mac
Segment 3	-0.306 to -0.123	17.9 to 36.2 % mac
Segment 4	-0.400	0.085 % mac
Segment 5	-2.89	-240.0 % mac
Segment 6	-1.026 to -0.226	-54.1 to 25.9 % mac

Table 2: Calculated Center of Gravity with corrected $\delta C_m/\delta C_L$

Dayton Approach Issue

In their post docket additional comments, Boeing suggested that the shift in the elevator trace at 6210 sec during the Dayton landing be investigated. Figure 23 from the original report showed this shift and is reproduced below as figure 2.

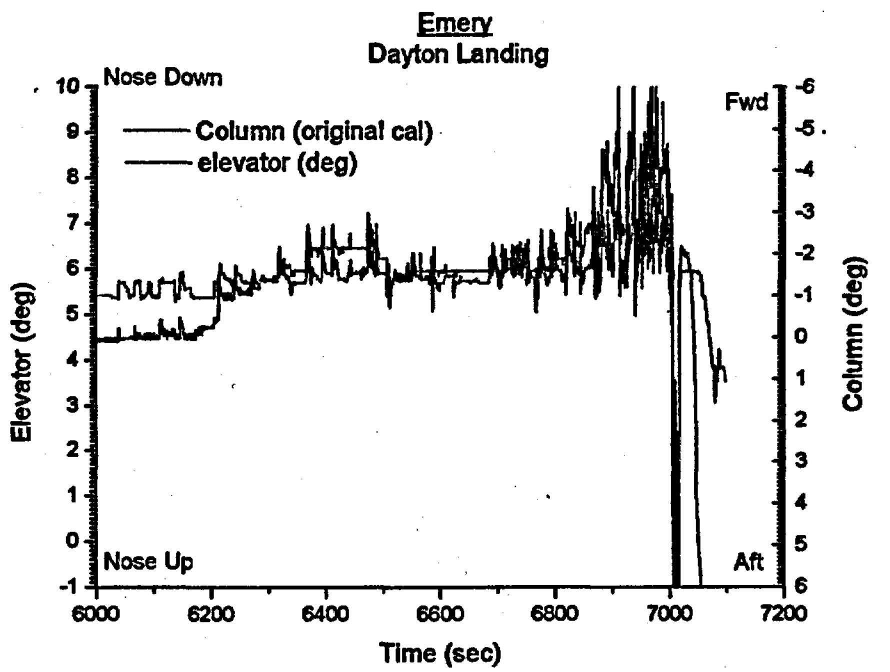

Figure 2: Dayton Landing Controls

The cross-plot in Figure 25 of the original report is reproduced below as figure 3 with data before the 6210 sec elevator shift highlighted in red.

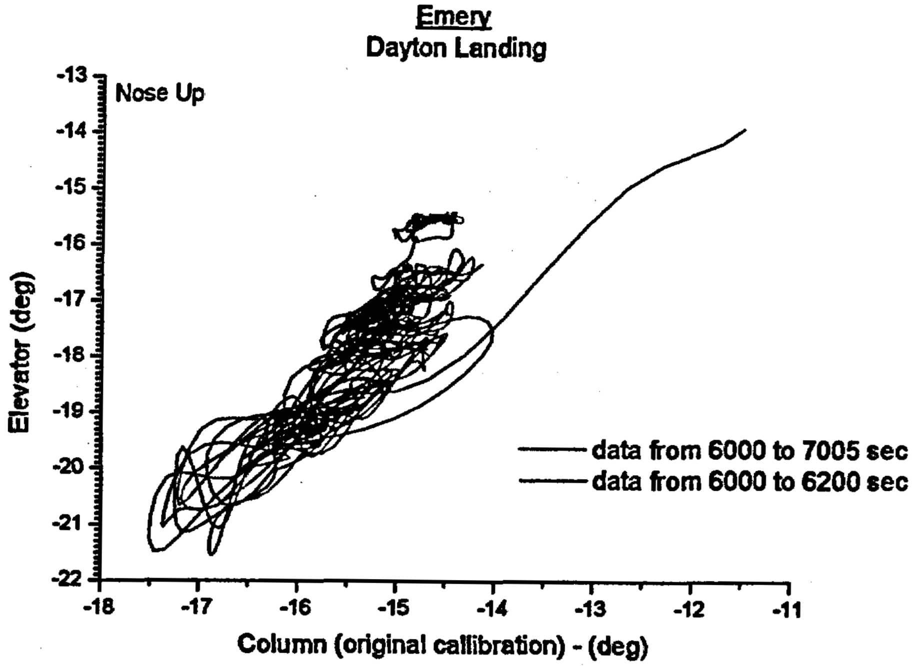

Figure 3: Dayton Landing Cross-plot

The cross-plot of the Dayton approach is compared to the cross-plot of the approach into Mather field in figure 4.

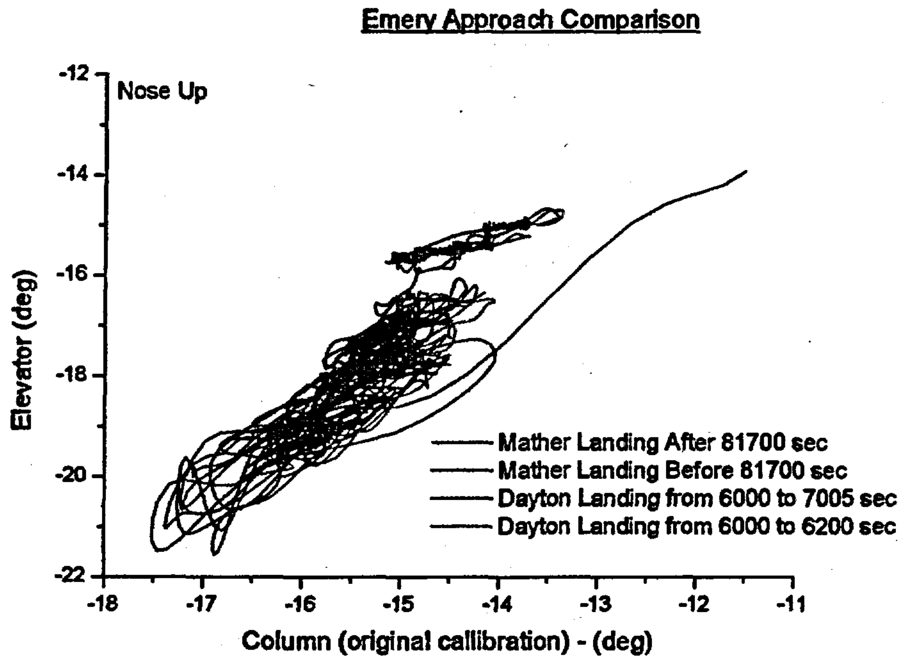

Figure 4: Comparison of Dayton and Mather approaches

The Kinsurf program was used to extract control parameters covering the time of the elevator shift. Since weight and center of gravity for the Dayton approach was not available, the weight and center of gravity for the approach into Mather field was used. This was 225719 lbs at 27.1% mean aerodynamic chord. Any error introduced by this approximation should shift the derived stabilizer trace but not affect any relative changes at 6210 sec.

As outlined in the original report, the measured FDR column was converted to a column with zero reference perpendicular to the floor by adding 13.5 deg. FDR elevator was converted to the standard convention used by the aerodynamic model by reversing the sign and subtracting 11 deg. The original report showed that the zero column force, aircraft equilibrium trim condition was satisfied with a further 3.2 deg trailing edge up offset to elevator and with no additional offset to column. These corrections were applied to the column and elevator for this study.

Kinsurf was first run to extract stabilizer from aircraft motion using elevator as input. The extracted stabilizer is shown in figure 5 together with elevator and column. Note that the analysis assumed zero winds and turbulence. Winds and turbulence actually present will be reflected in noise in the extracted stabilizer trace.

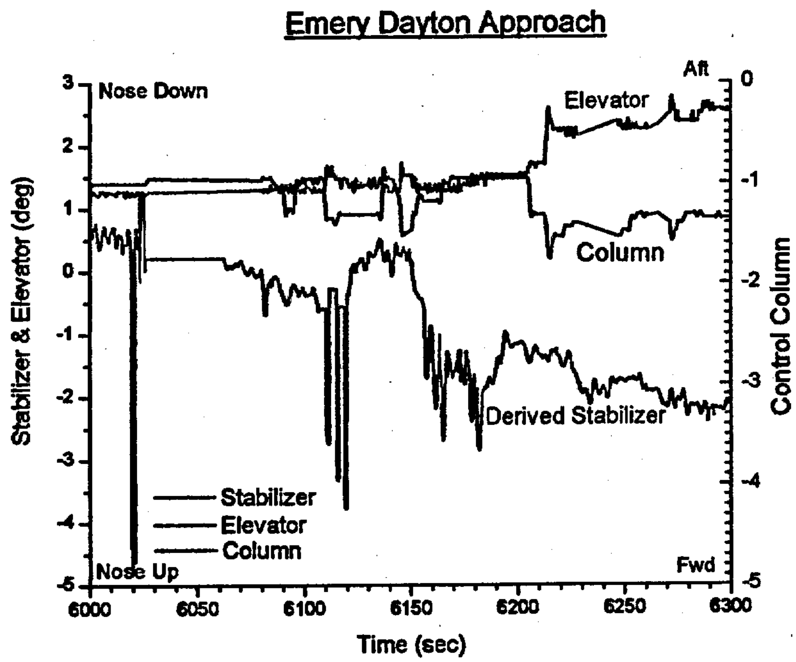

Figure 5: Extracted Stabilizer and pitch controls.

As can be seen in figure 6, the aircraft had leveled out just before the trim change that began about 6150 seconds.

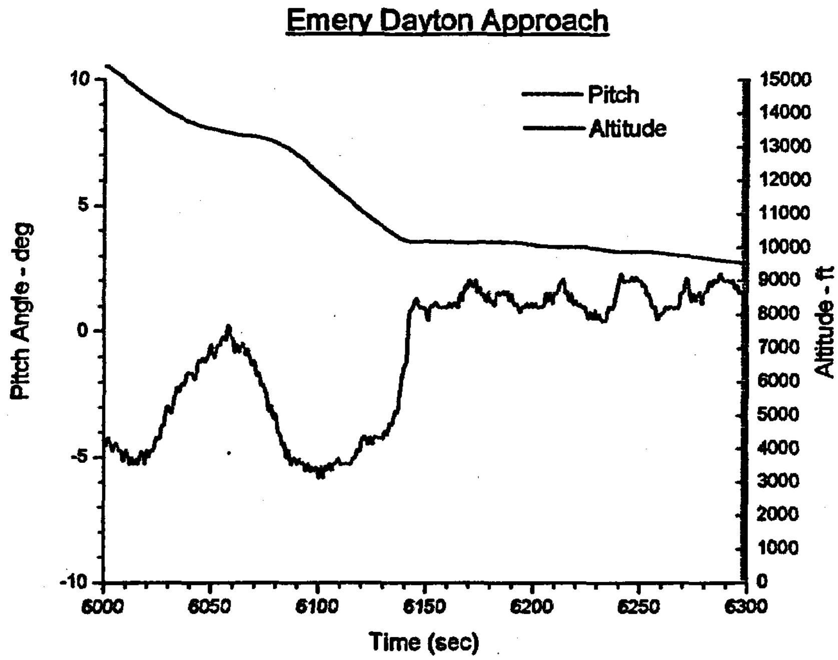

Figure 6: Flight path profile

With the stabilizer trace established, Kinsurf was then run in the mode to extract control tab deflection. As before, the left tab operates normally as a function of column and elevator position. The right tab is calculated to provide the hinge moment required to balance the elevator at the elevator deflection. The resulting control tab deflections are shown in figure 7.

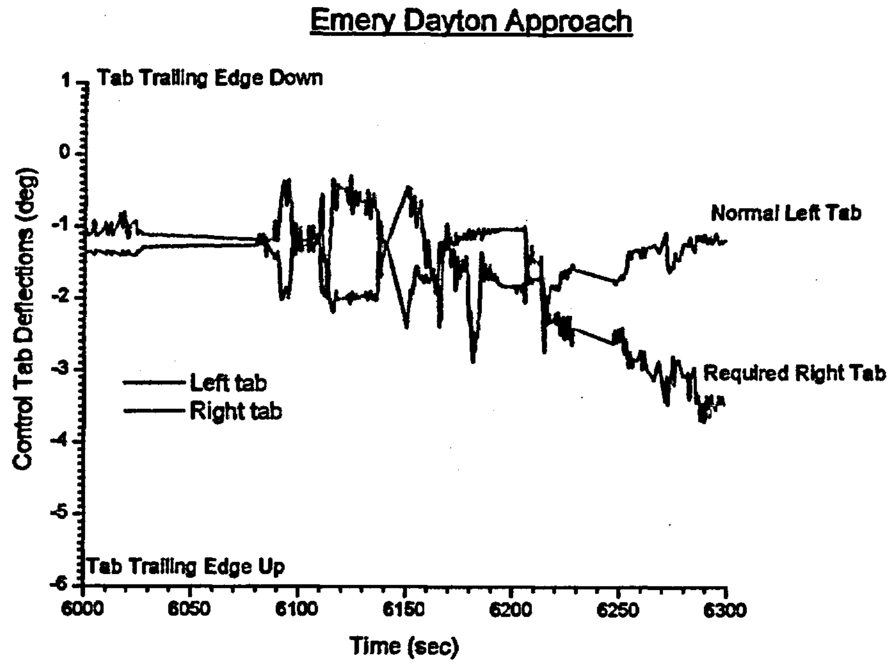

Figure 7: Control tabs

The right control tab required to balance the elevator is primarily a function of the left control tab deflection and the elevator deflection[1] and horizontal tail angle of attack. To aid in the understanding of the extracted right tab, the right tab is plotted together with the left control tab, elevator deflection and tail angle of attack in figure 8. Note that a flap extension to 5 deg is assumed to occur when the aircraft slows through 210 kts (at 6274 sec). With the weight unknown, this flap extension could have occurred earlier.

[1] Note that geared tabs are included in the effect of elevator deflection.

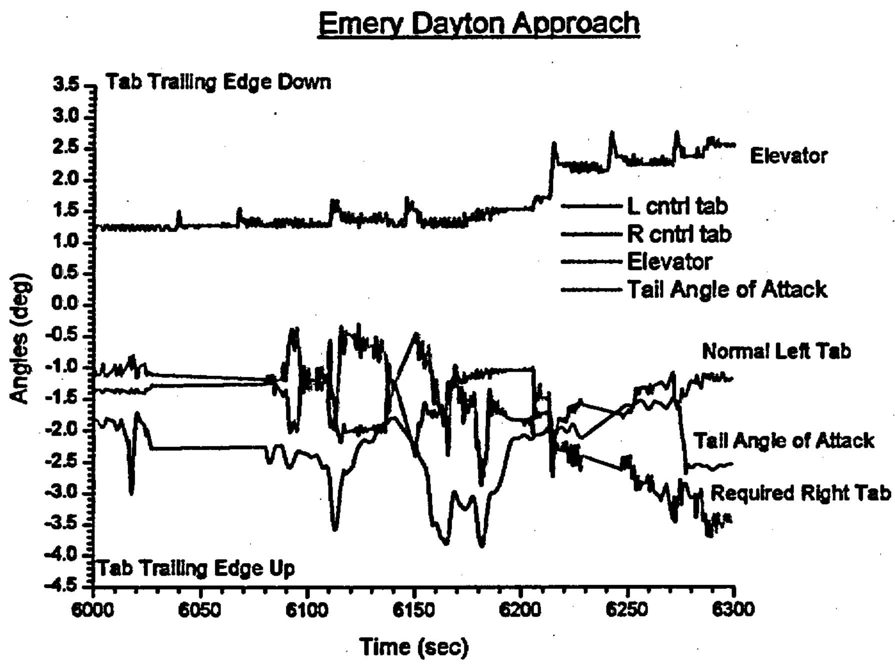

Figure 8: Control tabs with elevator

The stick force is plotted in figure 9. Note that the control system motion at 6210 sec relieves the 7 lb pull stick force held before the movement. Note also that the stick force indicates proper trim at the beginning of the event.

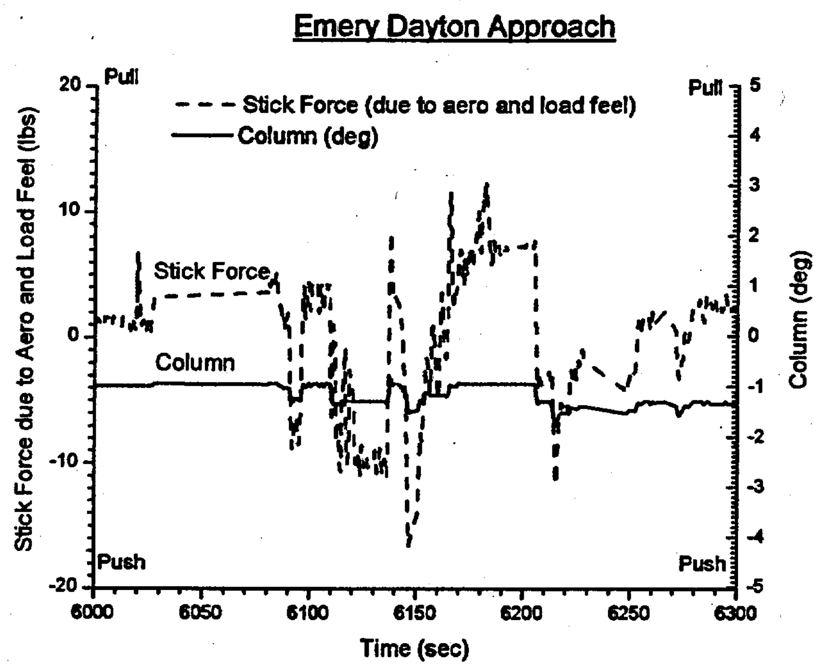

Figure 9: Column Force

Summary

The Kinsurf code was modified to use of the corrected FDR elevator rather than the Kinsurf derived elevator when removing the effect of elevator from longitudinal stability. The use of the corrected FDR elevator has resulted in a larger derived center of gravity scatter than the Kinsurf extracted elevator method but also shows no indication of an aft center of gravity.

The shift in the elevator trace at 6210 sec during the Dayton landing has been investigated. The shift in derived tab at this point is less than one degree.

[redacted]

Dennis Crider
National Resource Specialist
Aircraft Simulation