DOCKET NO: SA-510

EXHIBIT NO: 9AG

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

BOEING 737 FAILURE ANALYSIS SUMMARY

Summary of Boeing 737 Failure Analysis of the 737 Rudder Control System (D6-14072)

During the design and certification of the Boeing 737 series airplanes, a failure analysis was conducted on the rudder control system. That analysis along with Boeing testing provided the basis of compliance with applicable Federal Aviation Regulations in effect at the time of certification. Because of Boeing proprietary considerations this analysis has been summarized. The following describes, in paraphrased form, the analysis considered relevant to testimony for the public hearing held in conjunction with the investigation of the USAir flight 427 accident near Pittsburgh, PA. Note that this summary is not all-inclusive of the analysis performed and is presented in abbreviated form. Other failure conditions and additional detail is provided in the Boeing document (D6-14072).

Lateral Control System

The failure analysis indicates that Boeing believes that the following failures of the rudder control system could be countered by the use of the airplane's lateral control system:

1. Failure of the manual control system between the rudder pedals and the forward rudder quadrants at the pilot's station.
2. Failure of the manual control system between the feel-centering-trim control unit and the input crank at the lower end of the dual torque tube assembly.
3. Failure of the manual control system in the dual torque tube assembly, between the manual input crank and the output cranks to the main and standby position servos.
4. Failure of the manual control system between the dual torque tube assembly, lower output crank and the input lever to the control valve on the main position servo including the external summing lever.
5. Failure of the manual control system between the dual torque tube assembly, upper output crank and the input lever to the hydraulic control valve on the standby position servo.
6. Failure of the trim system and feel and centering system mechanisms..
7. Failure of the hydraulic control valve in the main position servo.
8. Failure of the linkages between the yaw damper mod-piston assembly and the main hydraulic control valve, in the main position servo.
9. Failure of the hydraulic actuator assembly in the main position servo.
10. Failure of the input linkage to the hydraulic control valve in the standby position servo.
11. Failure of the hydraulic control valve in the standby position servo.

Failures of the manual control system between the rudder pedals and the forward rudder quadrants at the pilot's station could be overcome by the use of the rudder trim system to the extent of trim authority.

Disabling the Airplane's Hydraulic System

For the failures of the following systems or components, Boeing analysis suggests disabling the airplane's main hydraulic systems:

1. Failure of the linkages and cams between the hydraulic actuator and the output shaft in the feel and centering unit.
2. Failure of the manual control system between the feel-centering-trim control unit and the input crank at the lower end of the dual torque tube assembly.
3. Failure of the manual control system in the dual torque tube assembly, between the manual input crank and the output cranks to the main and standby position servos.
4. Failure of the manual control system between the dual torque tube assembly, lower output crank and the input lever to the control valve on the main position servo including the external summing lever.
5. Failure of the manual control system between the dual torque tube assembly, upper output crank and the input lever to the hydraulic control valve on the standby position servo.(In the event of a off-centered jammed position).
6. Failure of the manual input linkage to the hydraulic control valve in the main position servo.
7. Failure of the linkages between the yaw damper mod-piston assembly and the main hydraulic control valve, in the main position servo.
8. Failure of the hydraulic actuator assembly in the main position servo.

[redacted]

Gregory Phillips January 20, 1995
Aerospace Engineer
National Transportation Safety Board