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

May 15, 2000

SYSTEMS GROUP CHAIRMAN'S FACTUAL REPORT

A. ACCIDENT **DCA00MA030**

Location	:	Burbank, California
Date	:	March 5, 2000
Time	:	1811 Pacific Standard Time
Airplane	:	Southwest Airlines Flight 1455, Boeing 737-3T5, N668SW

B. SYSTEMS GROUP

Chairman	:	Joseph M. Sedor National Transportation Safety Board [redacted]
Member	:	Charles Smits Southwest Airlines
Member	:	Terrence McMaster Federal Aviation Administrations
Member	:	Carl Anderson Teamsters Union
Member	:	Jeff Hefner SWAPA
Member	:	Chris Stanley Teamsters Union
Member	:	Roy Lain Southwest Airlines
Member	:	Rodney Beaver Southwest Airlines

C. SUMMARY

On Sunday, March 5, 2000, at 1811 PST, a Southwest Airlines Boeing 737-300, N668SW, operating as flight 1455 from Las Vegas, Nevada, overran the departure end of runway 08 following a landing at Burbank-Glendale-Pasadena Airport, Burbank, California. The airplane traveled through a fence at the end of the runway and came to rest on a highway outside the airport perimeter. There were no fatalities to the 137 passengers and 5 crew aboard. The flight was on an IFR flight plan and was cleared for a visual approach to land. VFR weather conditions prevailed at the time.

Members of the Systems group met on scene from March 5 through March 10, 2000, to examine the airplane. The Systems Group Chairman arrived on scene on March 8, 2000. On the morning of March 6, 2000, the airplane was moved to an isolated part of the airport for further examination. The cabin emergency light battery packs were subsequently tested by members of the Systems group at the Southwest Airlines maintenance facility in Phoenix, Arizona, on March 30, 2000.

D. DETAILS OF THE INVESTIGATION

1.0 WHEELS/TIRES/BRAKES

1.1 Main Wheel Tires

The Boeing 737 has two main landing gear (MLG), each with two Goodyear Flight Leader radial tires. The MLG tires installed on N668SW were all recaps with reinforced treads. Both left MLG tires and the right outboard MLG tire were found deflated. The deflated tires were removed and replaced with new tire/wheel assemblies prior to moving the airplane on March 6, 2000.

All the MLG tires had uniform wear patterns and there was no evidence of flat spotting on any tire. The three deflated tires had large cuts and lacerations on both the tread surface and sidewalls, and were deformed due to side loads and impact damage. None of the fuse plugs appeared melted. The left inboard MLG tire was found pressurized and was measured to be 191 PSI (loaded). It had several metal shards imbedded on the tread surface and sidewall along with large cuts and lacerations.

The tread remaining on each tire was measured at four locations. Southwest Airlines replaces tires at a minimum tread depth of 1/32 inches and tire tread depth is 13/32 inches (nominal) when new.

Tire / Position	Left Outboard(1) (inches)	Left Inboard(1) (inches)	Right Inboard(1) (inches)	Right Outboard(1) (inches)
12 O'clock(3)	4/32, 5/32, 6/32, 4/32	7/32, 10/32, 10/32, 7/32	4/32, 6/32, 6/32, 7/32	3/32, 4/32, 4/32, 4/32
3 O'clock	5/32, 5/32, 5/32, 4/32	7/32, 8/32, 9/32, 8/32	5/32, 5/32, 5/32, 4/32	2/32, 2/32, 2/32, 4/32
6 O'clock	5/32, 5/32, 5/32, 3/32	7/32, 10/32, 10/32, 7/32	(2)	2/32, 4/32, 4/32, 4/32
9 O'clock	5/32, 7/32, 7/32, 5/32	7/32, 10/32, 10/32, 8/32	5/32, 5/32, 5/32, 4/32	2/32, 2/32, 2/32, 4/32

NOTES: 1. Each tire has four tread grooves. Left tire measurements from aircraft outboard to inboard and right tire measurements from aircraft inboard to outboard.
2. Could not be measured, due to tire still being installed on the airplane.
3. The inflation stem was designated as 12 O'clock.

1.2 Main Wheel Brakes

The four MLG brake assemblies were in good condition. There was no indication of excessive overheat or impact damage. Due to the minimal damage to the hydraulic brake system, the group decided to functionally check the brakes utilizing a hydraulic cart. Prior to testing, several hydraulic lines in the vicinity of the MLG were repaired due to damage incurred while moving the airplane on March 6, 2000 (post-accident). Also, the hydraulic lines to the thrust reversers, leading edge flaps and slats, and nose gear were capped to prevent leakage due to accident related damage.

Examination of the cockpit brake pedal system revealed that the left pedal on the Captain's side was jammed in a partially deflected position but the right brake pedal, on the same side, could move freely. The transfer tube between the Captain's and First Officer's left brake pedal was found bent and wedged between crushed structure. Full movement of the Captain's left pedal was restored after it was mechanically disconnected from the transfer tube.

A hydraulic cart was obtained from another operator and connected to the B hydraulic system. (The hydraulic cart was not calibrated prior to testing.) There were no hydraulic leaks noted in any B hydraulic lines when the system was pressurized and the brake system accumulator gage indicated 3,000 PSI. The Captain's brake pedals were operated and all the brake pistons were observed to move freely when pressure was cycled. The parking brake was then set and each brake wear pin measured. After the wear pins were measured, pressure gages were connected to each brake and the individual pressures recorded with the Captain's brake pedals held at full deflection. The following table summarizes the measurements obtained from the brake tests.

	Left Outboard Brake	Left Inboard Brake	Right Inboard Brake	Right Outboard Brake
Wear Pin Remaining (Inches)	19/32"	23/32"	11/16"	1 11/32"
Brake Pressure (PSI)	2,800 PSI	2,800 PSI	2,800 PSI	2,800 PSI
Released Pressure (PSI)	0 PSI	0 PSI	0 PSI	500 PSI (1)

NOTES: 1. Gage read 500 PSI after it was disconnected.

2.0 FLIGHT CONTROLS

No pre-impact failures were noted in the aileron, elevator or rudder systems. No pre-impact failures were noted in the leading and trailing edge flaps and slats. Flight Data Recorder (DFDR) data show the airplane touched down with flaps extended to 30 units at

approximately 181 knots. The flaps then extended to 40 units during the ground roll at about 150 knots. The Boeing 737 is configured with a flap load limiter system. The flap handle can be placed in the 40 unit detent above 160 knots, however, the flap panels will not extend to the 40 unit position until the airspeed is below about 160 knots.

DFDR data show symmetrical left and right thrust reverser deployment after touchdown and no pre-impact failure to either thrust reverser was noted.

2.1 Boeing 737 Spoiler System Description

The Boeing 737 has 5 spoiler panels on each wing (see Appendix B for diagram). The spoiler panels are number 0 through 9 from left to right. Spoilers 2, 3, 6, and 7 are flight spoilers and used for lateral control, reducing airspeed in flight, and to aid braking after touchdown. Spoilers 0, 1, 4, 5, 8, and 9 are ground spoilers and only used on the ground after touchdown to aid braking.

Cockpit control wheel rotation directs flight spoiler motion for lateral control. Input to the spoiler control system is normally through an aileron spring cartridge which connects the aileron bus drums to a spoiler ratio changer. A spoiler mixer then combines the lateral control inputs with spoiler inputs to move the control cables routed along the rear spars of the wings to the spoiler actuators. In addition, the flight spoilers can also be extended via the speed brake control lever to increase drag in flight or on the ground. The flight spoilers can be extended to a maximum of 40° from the faired position.

The ground spoilers can be extended only on the ground by moving the speed brake control lever which rotates the speed brake forward drum mechanism. The forward drum is connected by cables to the speed brake quadrant which provides an input to the spoiler ratio changer and mixer. The spoiler mixer then opens the ground spoiler control valve in the right wheel well directing hydraulic power to the spoiler actuators. A ground spoiler interlock valve is installed in the hydraulic line between the ground spoiler actuators and the ground spoiler control valve. The interlock valve is operated by a cable connected to the right main landing gear, and opens when the airplane touches down and the shock strut is compressed. The ground spoilers have two positions, fully retracted or fully extended to 60°.

The speed brake control lever can be moved either manually or automatically by the speed brake lever actuator. The actuator is a 28 volt DC electric motor located below the cockpit center pedestal (see Appendix B for diagram). If the speed brake control lever is placed in the ARMED detent, the speed brake lever actuator will automatically move the lever to the extend position, thus extending the spoilers, upon main wheel spin-up or air/ground transition. If the lever is not ARMED, the actuator will move the speed brake control lever to the extend position when the thrust reversers are deployed and wheel speed is greater than 60 knots. The lever actuator will retract the spoiler control lever if either engine throttle is advanced 25° forward from the idle position.

The speed brake control lever position ranges from 0° to 50°. As the lever is moved to the extended position, the flight spoiler panels begin to extend at approximately 10° of lever and will be fully extended at 45° of lever. The ground spoilers are commanded full up at

approximately 27° of lever. Speed brake retraction is similar. In a high rate extension/retraction, the flight spoilers fully transition before the ground spoilers begin to move. The ground spoilers can lag the flight spoilers by as much as one second, depending on the input rate and hydraulic pressure and flow.

The outboard flight spoilers are powered by the B hydraulic system and the inboard flight spoilers and all ground spoilers are powered by the A hydraulic system. The ground spoilers contain a mechanical locking mechanism that locks the actuator in the retract position to prevent float if hydraulic pressure is lost. The flight spoilers contain an extension check valve to prevent float if hydraulic pressure is lost.

2.2 N668SW Spoiler System

2.2.1 Spoiler Panels

Several spoiler panels on each wing were damaged (see photographs in Appendix A). Scrapes on the left upper wing skin began on the wing skin and crossed onto spoiler 2 and continued on to spoiler 3. The scrape pattern was continuous. Similarly, on the right wing, several scrapes were found on the wing skin and spoiler 6 in a continuous pattern.

The inboard trailing edge corner on spoiler 1 was fractured in downward direction (see photographs in Appendix A). A portion of the trailing edge was resting on the leading edge of the flap, however, there was no damage (i.e. no scrapes, marks, or paint transfer) to the leading edge of the flap. The panel was free to be lifted by hand (all other spoiler panels could not be lifted). The panel locked down when manually pushed to the fully stowed position.

The inboard trailing edge corner on spoiler 8 was fractured in the downward direction with portions of the upper skin stripped off (see photographs in Appendix A). The corner was resting on the leading edge of the flap, however, there was no damage to the leading edge of the flap (i.e. no scrapes, marks, or paint transfer).

2.2.2 Spoiler Controls

The cockpit speed brake control lever was found in the DOWN (spoilers retracted) position. Inspection of the speed brake lever actuator (P/N R5303-5, S/N 21009) revealed no visible damage. The ram output tube was found extended approximately 2 inches from the housing to the bottom of the stop nut. The GEC-Marconi Aerospace Inc. Overhaul Manual indicates that the operating stroke of the output tube is 1.99 $\pm$ .020 inches (see diagram in Appendix B.)

The speed brake control cables were found completely slack (i.e. zero cable tension) and resting on aircraft structure. (The group inspected the cable system after the airplane had been moved and the nose supported by a wood structure. The airplane originally came to rest on its nose following the accident. See Appendix A for photographs.) Continuity of the control cables system was verified by manually pulling on each side of the cable run and observing corresponding movement of the spoiler mixer.

2.2.3 Spoiler Hydraulic System

During the hydraulic brake functional tests, while the B hydraulic system was pressurized, flight spoilers 2 and 7 were manually operated by pulling on the spoiler control cables in the forward E/E bay. The spoilers operated normally, however, due to restrictions in the spoiler cable system or mixer (from impact damage), the spoiler deflection was limited to about 20°. The A hydraulic system was not pressurized.

There was no pre-impact failures noted to any spoiler system hydraulic line or valve in the wheel well area. The flexible drive rod, from the right main landing gear to the ground spoiler interlock valve, was not damaged. Additionally, there was no hydraulic fluid noted on the runway surface.

3.0 PITOT-STATIC SYSTEM

The Captain side pitot-static tubes were bent downward and cracked. The First Officer side pitot-static tubes were in good condition. Due to the damage to the Captains pitot-static tubes, the group removed the tubes and capped the lines. (The pitot-static lines are cross ported, that is, the Captains upper tube is cross connected with the lower First Officers tube, and the upper First Officer tube is cross connected to the lower Captains tube.) A pitot-static box was then attached to the First Officers upper and lower tubes and one minute leak checks performed. No leaks were noted in either system.

4.0 ELECTRONICS AND EQUIPMENT COMPARTMENT

The nose gear was turned 90° to the right and folded back into the electronics and equipment (E/E) compartment. The main battery was disconnected prior to inspection by the group. The E1 electronics rack was severely damaged and forced upwards. The aft connectors and wiring to several LRUs were damaged. The E2 and E3 electronics racks were slightly deformed, but the LRUs could be removed easily. The main wire bundle from the E2 electronics rack, which crosses in front of the E1 rack, had multiple areas of damage.

5.0 CABIN EMERGENCY LIGHTING

The 6 volt emergency battery packs were removed from the cabin and the batteries sent to a local repair station. The repair station tested the battery packs for the group, however, the group determined that the Component Maintenance Manual (CMM) procedures were not followed. The list of battery packs removed and results of the repair stations tests is included in Appendix C.

The battery packs were sent to Southwest's Maintenance Facility in Phoenix, Arizona, and tested in accordance with the CMM procedures on March 30, 2000, with FAA and Southwest Airlines personnel in attendance. The test results are included in Appendix C. Only one of the nine battery packs tested did not illuminate the lamps on the load bank.

The group, along with members of the Survival Factors group, tested the emergency light system on March 10, 2000, after new battery packs were installed on the accident

airplane. All the floor lighting, the door exit lights, and emergency exterior lights illuminated when the cockpit Emergency Light Switch was placed in the ARM or ON positions (cockpit switch was found in the ON position). Several rows of the bullnose (overhead baggage) lights, and the over-wing exit lights did not illuminate.

6.0 COCKPIT DOCUMENTATION

The group did not document the cockpit switch position prior to the airplane being moved. However, photographs were taken on the night of the accident and the operations group documented the switch positions on the following evening. Relevant cockpit readings and switch positions documented after the airplane was moved are included in Appendix D.

[redacted]
Joseph M. Sedor
Systems Group Chairman
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6/9/00