

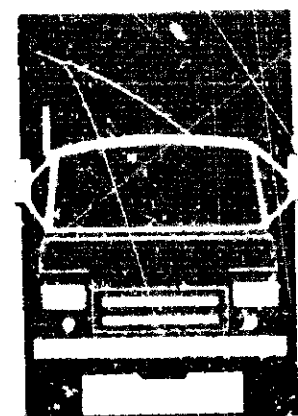
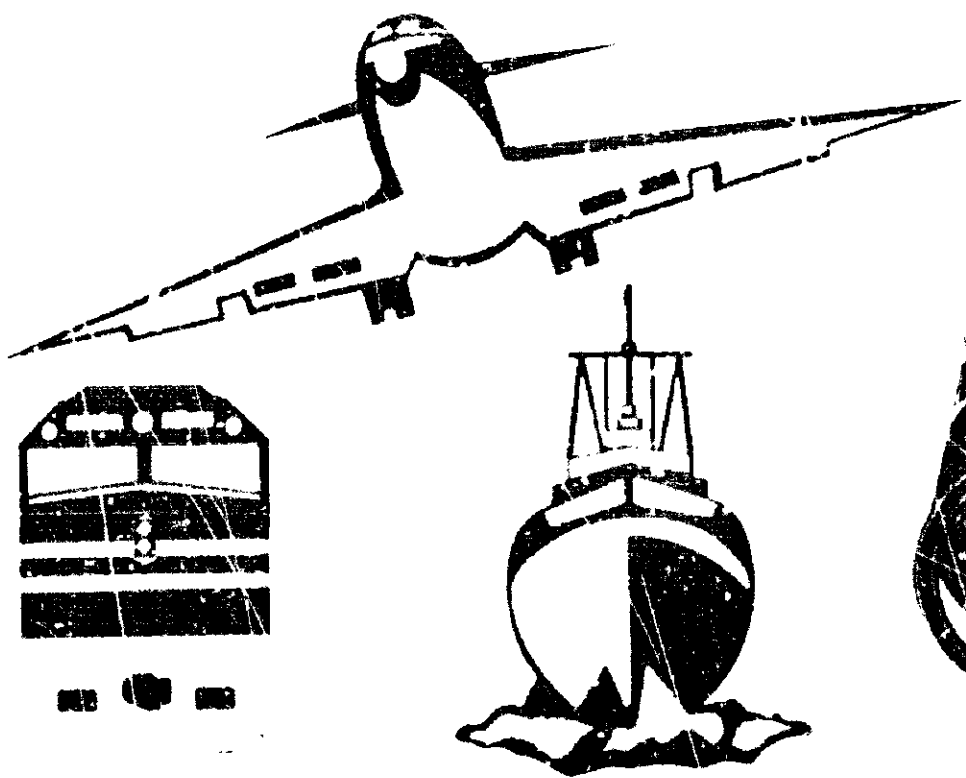
PB92-910402
NTSB/AAR-92/02
(SUPERSEDES NTSB/AAR-90/01)

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

EXPLOSIVE DECOMPRESSION--
LOSS OF CARGO DOOR IN FLIGHT
UNITED AIRLINES FLIGHT 811
BOEING 747-122, N4713U
HONOLULU, HAWAII
FEBRUARY 24, 1989



5059C

3. CONCLUSIONS

3.1 Findings

1. There were no flightcrew or cabincrew factors in the cause of the accident or injuries.
2. There were no air traffic control or weather factors in the cause of the accident.
3. The airplane had not been maintained in accordance with the provisions of AD-88-12-04 that required an inspection of the cargo door locking mechanisms after each time the door was operated manually and restored to electrical operation. However, this circumstance was determined not to be a factor in the accident.
4. All but one of the electrical components remaining with the airplane or found with the cargo door that were necessary to have malfunctioned in order to cause an inadvertent electrical opening of the cargo door after dispatch were found to function properly.
5. The forward cargo door lock sectors were found in the locked position (actually in an "over-locked" position) and jammed against the latch cams. The latch cams were found in the nearly open position.
6. The latch actuator manual drive port seal was found damaged from the forces involved in the separation of the door and did not indicate that the drive port had been used to open the door latches manually before the accident.
7. Electrical continuity tests indicated that the S2 master latch lock switch was in the "not locked" position when it was recovered with the cargo door. Because it had sustained damage from being submerged in the sea, its preaccident condition could not be determined.

8. An S2 switch functioning as found after recovery would permit electrical power to the door during ground operation so that additional failure modes or activation of the door control switch could result in movement of the latching cams.
9. All other switches associated with operation of the cargo door were found damaged from being submerged in the sea; however, they were determined to be properly installed and probably functional.
10. Short circuit paths in the cargo door circuit were identified that could have led to an uncommanded electrical actuation of the latch actuator; this situation occurred most likely before engine start, although limited possibilities for an uncommanded electrical actuation exist after engine start while an airplane is on the ground with the APU running.
11. It was not possible for electrical short circuits to command the cargo door to open at the time of the loss of the door, and it is highly improbable that such an event occurred when the airplane was airborne during the short period while the APU was running.
12. Insulation breaches were found on recovered portions of the cargo door wires that could have allowed short circuiting and power to the latch actuator, although no evidence of arcing was noted. All of the wires were not recovered, and tests showed that arcing evidence may not be detectable.
13. An uncommanded movement of cargo door latches that occurred on another UAL B-747 on June 13, 1991, was attributed to insulation damage and a consequent short between wires in the wiring bundle between the fuselage and the moveable door. Because the S2 switch functioned properly on that airplane, movement of the latches would not have occurred after the door was locked.
14. UAL's maintenance trend analysis program was inadequate to detect an adverse trend involving the cargo door on N4713U.

This circumstance was determined not to be a factor in the accident.

15. FAA oversight of the UAL maintenance and inspection program did not ensure adequate trend analysis and adherence to the provisions of airworthiness directives. This circumstance was determined not to be a factor in the accident.
16. The smooth wear patterns on the latch pins of the forward cargo door installed on N4713U were signs that the door was not properly aligned (out of rig) for an extended period of time, causing significant interference during the normal open/close cycle.
17. The rough heat-tinted wear areas on the latch pins of the forward cargo door installed on N4713U marked the positions of the cams at the time the door opened in flight.
18. The design of the B-747 cargo door locking mechanisms did not provide for the intended "fail-safe" provisions of the locking and indicating systems for the door.
19. Boeing's Failure Analysis, which was the basis upon which the FAA granted an alternative method of compliance with the provisions of 14 CFR 25.783 (e), was not valid as evidenced by the findings of the Pan Am incident in 1987, and the accident involving flight 811.
20. Boeing and the FAA did not take immediate action to require the use of the cam position view ports following the Pan Am incident, and did not include this requirement in the provisions of the Alert Service Bulletins or AD-88-12-04.
21. There were several opportunities for the manufacturer and the FAA to have taken action during the service life of the Boeing 747 that might have prevented this accident.
22. The fact that the crash fire rescue vehicles responding to this accident did not use a common radio frequency led to problems in communication among the responding vehicles.

23. The camouflage paint scheme of the military fire rescue units led to reduced visibility of these units and resulted in at least one near-collision.
24. Megaphones were used in flight to communicate with passengers because of the high ambient noise level. However, more megaphones would have afforded better communication in all parts of the cabin.
25. Some flight attendants and passengers had difficulties tightening straps of their life preservers around their waists because of the fabric used, the design of the adjustment fittings, and the angle the straps were pulled.
26. Articles that fell to the floor from stowage bins above the L-2 and R-2 exits and galley service items had to be cleared away from the exits before the emergency evacuation could be initiated.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the sudden opening of the forward lower lobe cargo door in flight and the subsequent explosive decompression. The door opening was attributed to a faulty switch or wiring in the door control system which permitted electrical actuation of the door latches toward the unlatched position after initial door closure and before takeoff. Contributing to the cause of the accident was a deficiency in the design of the cargo door locking mechanisms, which made them susceptible to deformation, allowing the door to become unlatched after being properly latched and locked. Also contributing to the accident was a lack of timely corrective actions by Boeing and the FAA following a 1987 cargo door opening incident on a Pan Am B-747.

4. RECOMMENDATIONS

As a result of the investigation, including evidence from the recovered cargo door and a June 13, 1991, incident involving the uncommanded electrical operation of a cargo door on a UAL Boeing 747 at JFK Airport, the National Transportation Safety Board recommends that the FAA:

Require that the electrical actuating systems for nonplug cargo doors on transport-category aircraft provide for the removal of all electrical power from circuits on the door after closure (except for any indicating circuit power necessary to provide positive indication that the door is properly latched and locked) to eliminate the possibility of uncommanded actuator movements caused by wiring short circuits. (Class II, Priority Action) (A-92-21)

As a result of this investigation, on August 23, 1989, the Safety Board issued the following safety recommendations to the FAA:

Issue an Airworthiness Directive (AD) to require that the manual drive units and electrical actuators for Boeing 747 cargo doors have torque limiting devices to ensure that the lock sectors, modified per AD-88-12-04, cannot be overridden during mechanical or electrical operation of the latch cams. (Class II, Priority Action) (A-89-92)

Issue an Airworthiness Directive (AD) for non-plug cargo doors on all transport category airplanes requiring the installation of positive indicators to ground personnel and flightcrews confirming the actual position of both the latch cams and locks, independently. (Class II, Priority Action) (A-89-93)

Require that fail-safe design considerations for non-plug cargo doors on present and future transport category airplanes account for conceivable human errors in addition to electrical and mechanical malfunctions. (Class II, Priority Action) (A-89-94)

The FAA responded to Safety Recommendations A-89-92 through -94 on November 3, 1989. During its evaluation of Safety Recommendation A-89-92, the FAA determined that Boeing 747 cargo doors with lock sectors, modified in compliance with AD 88-12-04, cannot be overridden during mechanical or

least one torque-limiting device. The Safety Board has reviewed AD 88-12-04 and has confirmed the FAA's findings. Based on this, Safety Recommendation A-89-92 has been classified as "Closed--Reconsidered."

The FAA responded to Safety Recommendations A-89-93 and -94 describing action to review all outward opening (nonplug) doors and all jet-powered transport-category airplanes to determine what, if any, modifications are needed to ensure that these doors will not open in flight. The FAA pointed out that the door latch indicating system is to be only part of the review and that door designs will be evaluated against criteria specified in 14 CFR 25.783 as amended by Amendment 25-54, and the policy material published in Advisory Circular 25.783.1, adopted in 1980 and will take into account human factors involved in the routine operation of closing and locking doors to ensure that the latch and lock systems are fail-safe. Further, to emphasize the importance of human factors, the FAA has developed a training program for FAA certification personnel to enhance their knowledge of human factors in aircraft design. This training program will be offered to approximately 100 certification personnel during the next year. Based on this response, Safety Recommendations A-89-93 and -94 have been classified as "Open--Acceptable Action." The Safety Board believes it necessary to point out that this hazard exists for any pressurized aircraft using nonplug doors and that the FAA should not be limiting this review to only those transports which are jet-powered.

On November 29, 1990, Boeing issued service bulletin number 747-52-2224 applicable to all 747-100, 747-200, and 747-300 airplanes to add a new "door latch" switch to all 747 cargo doors.

In addition to the door warning switch that monitors the position of the pressure relief doors, the new door latch switch is activated by the latch cam bellcrank to separately sense the position of the latch cams. The existing "door closed" switch is also replaced with a double pole switch. The additional pole is used to separately sense the position of the door. Another single pole switch is also added to redundantly sense the position of the door. If any of these switches are not actuated, the warning light on the flight engineer's panel and a new light added to pilot's glareshield panel will be illuminated. The modification also requires installation of new cargo door control panels on the forward and aft lower cargo doors. The new panel incorporates an additional light to indicate proper door locking.

The FAA mandated the incorporation of this service bulletin within 18 months by AD 90-09-05, Amendment 39-6581, effective May 29, 1990.

Also, as a result of this accident, on May 4, 1990, the National Transportation Safety Board issued the following safety recommendations to the FAA:

Amend 14 CFR 25.1447(c)(4) to require that face masks be attached to the regulators of portable emergency oxygen bottles. (Class II, Priority Action) (A-90-54)

Require, in accordance with the requirements of 14 CFR 25.1447(c)(4), that a portable oxygen bottle be located at the flight attendant stations at exit door 5 right and at exit door 5 left in B-747 airplanes. (Class II, Priority Action) (A-90-55)

Require that no articles be placed in storage compartments that are located over emergency exit doors. (Class II, Priority Action) (A-90-56)

Amend 14 CFR 121.309(f) to require a readily accessible megaphone at each seat row at which a flight attendant is stationed. (Class II, Priority Action) (A-90-57)

Take corrective action to improve direct visibility to passengers from the upper level flight attendant jumpseat in the B-747 airplanes using eye reference data contained in Federal Aviation Administration report FAA-AM-75-2 "Anthropometry of Airline Stewardesses." (Class II, Priority Action) (A-90-58)

Issue an Airworthiness Directive to require that stronger latches be installed in oversized storage compartments that formerly held liferafts on all B-747 airplanes and also limit the distance that these compartments can be opened. (Class II, Priority Action) (A-90-59)

Demonstrate for each make and model of life preserver that it can be donned, adjusted, and tightened within the elapsed time required by TSO-C13d. Direct particular attention to the ease with which straps pass through adjustment fittings when the straps are pulled at all possible angles. (Class II, Priority Action) (A-90-60)

Establish a cutoff date of [within 1 year of this recommendation letter] after which all life preservers manufactured for passenger-carrying aircraft would be required to meet the specifications of TSO-C13e. (Class II, Priority Action) (A-90-61)

The FAA first responded to these safety recommendations in a July 26, 1990, letter. Further responses to various safety recommendations in the group came in letters dated October 26, 1990 (A-90-59); May 13, 1991 (A-90-58); September 23, 1991 (A-90-55, -56, and -59); and March 9, 1992 (A-90-59). The current status of each safety recommendation is:

A-90-54: "Open--Acceptable Response," pending outcome of potential rulemaking initiative by the FAA.

A-90-55: "Open--Unacceptable Response," pending a review by the FAA of B-747 airplanes for compliance with portable oxygen bottle placement and securement requirements and for modifications that do not meet the intent of the type certification.

A-90-56: "Open--Unacceptable Response," pending a reexamination by the FAA of the potential for contents of compartments spilling out during an emergency and obstructing passengers.

A-90-57: "Open--Unacceptable Response," pending the FAA's review of its position regarding a requirement for multiple megaphones on passenger airplanes.

A-90-58: "Closed--Reconsidered" as a result of the Safety Board's acceptance of the FAA position that the cabin jumpseat design on B-747's does not constitute an unsafe condition.

A-90-59: "Open--Acceptable Response," pending the issuance of an Airworthiness Directive to require stronger latches on oversized storage compartments on B-747 airplanes.

A-90-60: "Open--Acceptable Response," pending the implementation of the latest iteration of TSO-C13.

A-90-61: "Open--Unacceptable Response," pending inclusion in TSO-C13 (latest iteration) of a cutoff date after which all life

preservers manufactured for passenger-carrying aircraft would be required to meet the specifications of the TSO.

The FAA's March 9, 1992, response to Safety Recommendation A-90-59 included the final AD addressing this issue. The AD does meet the intent of the recommendation, which is now classified as "Closed--Acceptable Action."

Also as a result of this accident, on May 4, 1990, the Safety Board reiterated the following recommendations to the FAA:

A-85-35

Amend 14 CFR 121 to require that all passenger-carrying air carrier aircraft operating under this Part be equipped with approved life preservers meeting the requirements of the most current revision of TSO-C13 within a reasonable time after the adoption of the current revision of the TSO; ensure that 14 CFR 25 is consistent with the amendments to Part 121.

A-85-36

Amend 14 CFR 125 to require that all passenger-carrying air carrier aircraft operating under this Part be equipped with approved life preservers meeting the requirements of the most current revision of TSO-C13 within a reasonable time after the adoption of the current revision of the TSO; amend Part 125 to require approved flotation-type seat cushions (TSO-C72) on all such aircraft; ensure that 14 CFR 25 is consistent with the amendments of Part 125.

A-85-37

Amend 14 CFR 135 to require that all passenger-carrying air carrier aircraft operating under this Part be equipped with approved life preservers meeting the requirements of the most current revision of TSO-C13 within a reasonable time after the adoption of the current revision of the TSO; Amend Part 135 to require approved flotation-type seat cushions (TSO-C72) on all such aircraft; ensure that 14 CFR SFAR No. 23 is consistent with the amendments to Part 135.

In a November 28, 1988, letter to the FAA, the Safety Board recommended that a cutoff date January 1, 1989, be reestablished. Based on this accident, the Safety Board's again urges the FAA to establish a cutoff date by which life preservers meeting TSO-C13e would be introduced into the fleets within a reasonable time (A-85-36). The Safety Board recognizes that the FAA has complied with the part of this recommendation pertaining to the flotation-type seat cushions.

Safety Recommendations A-85-35 and -37 are being held in an "Open--Acceptable Action" status pending the publication of the final rule. Safety Recommendation A-85-36 is being held in an "Open--Unacceptable Action" status because Part 125 operations were not included in the FAA rulemaking action.

As a result of its investigation, on May 4, 1990, the Safety Board also recommended that the State of Hawaii, Department of Transportation, Airports Division:

Develop, in cooperation with the Department of Defense, procedures for direct radio communication between aircraft rescue and fire fighting vehicles operated by the State of Hawaii and Hickam Air Force Base that would be used when responding to airport emergencies at Honolulu International Airport. (Class II, Priority Action) (A-90-62)

Additionally, as a result of its investigation, on May 4, 1990, the Safety Board recommended that the Department of Defense:

Develop, in cooperation with the State of Hawaii Department of Transportation, procedures for direct radio communication between aircraft rescue and firefighting vehicles operated by Hickam Air Force Base and the State of Hawaii that would be used when responding to airport emergencies at Honolulu International Airport. (Class II, Priority Action) (A-90-63)

Comply with Federal Regulation 14 CFR 139.319(f)(2) and the guidance contained in Federal Aviation Administration Advisory Circular 150/5220-14 by using high visibility color for aircraft rescue and firefighting vehicles that operate at Honolulu International Airport. (Class II, Priority Action) (A-90-64)

The Department of Defense responded to Safety Recommendations A-90-63 and -64 on August 17, 1990, citing the establishment of emergency radio communication ability between ARFF vehicles operated by Hickam Air Force Base and the State of Hawaii at Honolulu International Airport. Based on this action, Safety Recommendation A-90-63 was classified as "Closed--Acceptable Action" on December 12, 1990. With the establishment of the communications system as recommended, the Safety Board now classifies Safety Recommendation A-90-62 as "Closed--Acceptable Action."

Also, with regard to Safety Recommendation A-90-64, the Department of Defense pointed out that the Air Force has initiated a program to repaint the vehicles over a 3-year period to spread out funding concerns. This safety recommendation is being held as "Open--Acceptable Response," pending the completion of the repainting program in 1993.

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