

3. CONCLUSIONS

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 N47 13U 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 CFP 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.