Inflight Cargo Fire
United Parcel Service Company Flight 1307
McDonnell Douglas DC-8-71F, N748UP,
Philadelphia, Pennsylvania
February 7, 2006

ACCIDENT REPORT

NTSB/AAR-07/07
PB2007-910408

National
Transportation
Safety Board

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Aircraft Accident Report

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490 L'Enfant Plaza, S.W.
Washington, D.C. 20594

National Transportation Safety Board. 2007. ***Inflight Cargo Fire, United Parcel Service Company Flight 1307, McDonnell Douglas DC-8-71F, N748UP, Philadelphia, Pennsylvania, February 7, 2006.*** **Aircraft Accident Report NTSB/AAR-07/07. Washington, DC.**

Abstract: This report explains the accident involving a McDonnell Douglas DC-8-71F, N748UP, operated by United Parcel Service Company, which landed at its destination airport, Philadelphia International Airport, Philadelphia, Pennsylvania, after a cargo smoke indication in the cockpit. The safety issues discussed in this report include inadequacies in the following areas: guidance and checklists relating to in-flight fire and smoke, smoke and fire detection system test certification requirements, fire suppression system requirements, aircraft rescue and firefighting training, cargo airplane emergency exit requirements, hazardous materials information dissemination procedures, and transport of lithium batteries on board aircraft. Safety recommendations concerning these issues are addressed to the Federal Aviation Administration, the Cargo Airline Association, and the Pipeline and Hazardous Materials Safety Administration.

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Abbreviations and Acronyms

AC	advisory circular
AEP	Airport Emergency Plan
AFFF	aqueous film-forming foam
ALPA	Air Line Pilots Association
AOM	Aircraft Operating Manual
AOMM	Airport Operations Methods Manual
ARFF	aircraft rescue and firefighting
ASOS	Automated Surface Observing System
ATC	air traffic control
ATCT	air traffic control tower
ATL	Hartsfield-Jackson Atlanta International Airport
ATP	airline transport pilot
C	Celsius
CAM	cockpit area microphone
CAR	Civil Aviation Regulations
CD	compact disc
CDU	control display unit
CFR	Code of Federal Regulations
CPSC	Consumer Product Safety Commission
CVR	cockpit voice recorder
DG	dangerous goods
DOT	Department of Transportation
FAA	Federal Aviation Administration
FDR	flight data recorder
FedEx	Federal Express Corporation
FOM	Flight Operations Manual
g	gram
HMIS	Hazardous Materials Information System
HMR	Hazardous Materials Regulations
HRET/SPN	high-reach extendable turret with skin-penetrating nozzle
ICAO	International Civil Aviation Organization
IFSTA	International Fire Service Training Association

InFO	Information for Operators
IPA	Independent Pilots Association
kg	kilogram
METAR	meteorological aerodrome report
msl	mean sea level
NPRM	notice of proposed rulemaking
NOTOC	notice to captain
PHL	Philadelphia International Airport
PHMSA	Pipeline and Hazardous Materials Safety Administration
PIC	pilot-in-command
QRH	Quick Reference Handbook
RSPA	Research and Special Programs Administration
SAFO	safety alert for operators
SAFT	Specialized Aircraft Fire Training
sm	statute mile
TEB	Teterboro Airport
TSB	Transportation Safety Board of Canada
UN	United Nations
UPS	United Parcel Service Company

Executive Summary

On February 7, 2006, about 2359 eastern standard time, United Parcel Service Company flight 1307, a McDonnell Douglas DC-8-71F, N748UP, landed at its destination airport, Philadelphia International Airport, Philadelphia, Pennsylvania, after a cargo smoke indication in the cockpit. The captain, first officer, and flight engineer evacuated the airplane after landing. The flight crewmembers sustained minor injuries, and the airplane and most of the cargo were destroyed by fire after landing. The scheduled cargo flight was operating under the provisions of 14 *Code of Federal Regulations* Part 121 on an instrument flight rules flight plan. Night visual conditions prevailed at the time of the accident.

The National Transportation Safety Board determines that the probable cause of this accident was an in-flight cargo fire that initiated from an unknown source, which was most likely located within cargo container 12, 13, or 14. Contributing to the loss of the aircraft were the inadequate certification test requirements for smoke and fire detection systems and the lack of an on-board fire suppression system.

The safety issues discussed in this report include inadequacies in the following areas: guidance and checklists relating to in-flight fire and smoke, smoke and fire detection system test certification requirements, fire suppression system requirements, aircraft rescue and firefighting training, cargo airplane emergency exit requirements, hazardous materials information dissemination procedures, and transport of lithium batteries on board aircraft. Safety recommendations concerning these issues are addressed to the Federal Aviation Administration, the Cargo Airline Association, and the Pipeline and Hazardous Materials Safety Administration.

1. Factual Information

1.1 History of Flight

On February 7, 2006, about 2359 eastern standard time,[1] United Parcel Service Company (UPS) flight 1307, a McDonnell Douglas DC-8-71F,[2] N748UP, landed at its destination airport, Philadelphia International Airport (PHL), Philadelphia, Pennsylvania, after a cargo smoke indication in the cockpit. The captain, first officer, and flight engineer evacuated the airplane after landing. The flight crewmembers sustained minor injuries, and the airplane and most of the cargo were destroyed by fire after landing. The scheduled cargo flight was operating under the provisions of 14 *Code of Federal Regulations* (CFR) Part 121 on an instrument flight rules flight plan. Night visual conditions prevailed at the time of the accident.

The accident occurred on the second day of a 5-day, 8-leg trip sequence for the flight crew. The airplane pushed back from the gate at Hartsfield-Jackson Atlanta International Airport (ATL), Atlanta, Georgia, and departed for PHL about 2241. The first officer was the flying pilot, and the captain performed the duties of the pilot monitoring.

The accident flight crew reported that the flight was uneventful until just after beginning the descent to PHL. At 2334:39, while the airplane was descending through flight level 310[3] about 50 nautical miles southwest of Washington, D.C., the cockpit voice recorder (CVR)[4] recorded the first officer asking the captain and the flight engineer if they detected an odor that smelled "like wood burning." The flight engineer replied that he had "smelled it for a couple of seconds." About 1 minute later, the first officer stated, "[it's] pretty strong now." Subsequently, the CVR recorded a sound similar to the cockpit door or seat operating and the flight engineer stating, "[it's] more in the back."[5] About 3 1/2 minutes later, the first officer again stated that the odor smelled like wood, and the flight engineer agreed that the odor did smell like wood burning and stated that it did not smell electrical in nature.

[1] Unless otherwise indicated, all times in this report are eastern standard time based on a 24-hour clock.

[2] McDonnell Douglas is now owned by the Boeing Commercial Airplane Group.

[3] Flight level 310 is an altitude of 31,000 feet mean sea level (msl) based on an altimeter setting of 29.92 inches of mercury. Unless otherwise indicated, all altitudes referenced in this report are reported as height above msl.

[4] Correlation of the CVR recording to eastern standard time was established using times from the air traffic control transcript prepared by the Federal Aviation Administration.

[5] In postaccident interviews, the flight engineer stated that he pulled back the smoke curtain and shined a flashlight along the left wall of the main cargo compartment. He stated that he could smell the odor but that he did not see any smoke or fire. The smoke curtain is a ventilation barrier that covers the cargo netting, which is located between the forward galley area and the main cargo compartment.

During postaccident interviews, the captain stated that he considered diverting to another airport soon after the odor was first detected but that he chose to continue to PHL because there was no evidence of a problem, such as the illumination of the cargo smoke warning lights. The first officer stated that the odor did not appear to be a threat because the flight engineer did not see any visible smoke; therefore, the first officer did not believe that there was any need to divert. Further, the accident flight crew stated that unusual odors could be common from nonthreatening factors (such as flying over forest fires or unusual cargo).

Over the next 4 minutes, the captain and flight engineer tried to identify the source of the odor by conducting several emergency checklist steps,[6] including increasing the bleed air flow and checking the bleed air switches. As the airplane was descending through about 18,000 feet and was about 65 miles from PHL, the CVR recorded the flight engineer stating that he set the air conditioning packs to maximum flow and turned off the recirculation fan. Shortly thereafter, the flight engineer and captain conducted the Approach checklist.

At 2344:59, the first officer contacted the PHL Terminal Radar Approach Control, and the approach controller instructed the flight to descend to 6,000 feet. The CVR then recorded the captain asking, "can you still smell it in the back there?" The flight engineer replied, "yeah . . . smells like it was more to the back there." The first officer then asked, "smells like cardboard burning doesn't it? you didn't see smoke though something like that?" The flight engineer again went back to check the main cargo compartment with his flashlight, and he stated that the odor was "definitely stronger in the back" but that there was no smoke or haze. Over the next 10 minutes, the captain and flight engineer continued to troubleshoot the problem.

At 2354:42, as the airplane was descending through about 3,600 feet, the flight engineer stated, "we got cargo smoke."[7] The captain replied, "let's do that checklist if you got time." The first officer then stated that he would be turning toward the airport. At 2355:01, the PHL approach controller cleared the visual approach to runway 27R and then instructed the flight crew to contact the air traffic control tower (ATCT). Ten seconds later, the captain made initial contact with the ATCT local controller, who cleared the flight to land on runway 27R. After acknowledging the clearance, the captain reported that the cargo smoke indicator had illuminated and requested that emergency response equipment meet them upon landing. The local controller immediately activated the crash phone and advised approach control of the emergency.

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[6] The UPS DC-8 Aircraft Operating Manual does not contain specific procedures on how to respond to in-flight smoke, fire, or fumes in the absence of a cockpit warning. See section 1.17 for additional information about these procedures.

[7] The flight engineer stated that his comment referred to the illumination of the Cargo Smoke warning light, which indicates the detection of smoke in the main cargo compartment.

At 2355:57, the flight engineer stated, "[it's] showing that we have a lower aft cargo fire section C."[8] Subsequently, the captain told the first officer and flight engineer to don their oxygen masks if they had not done so already. The captain then asked the flight engineer to accomplish the Lower and/or Main Cargo Compartment Smoke or Fire checklist by himself, and the flight engineer proceeded to execute the checklist.

According to air traffic control (ATC) transcripts, the Philadelphia approach controller asked the PHL ATCT local controller whether the flight was going to land on the left side, referring to runway 27L, which is the runway at PHL designated for use in emergency situations. At 2356:12, the local controller cleared the flight to land on runway 27L, and the captain acknowledged the landing clearance but not the change in landing runway.[9]

The flight engineer continued the Lower and/or Main Cargo Compartment Smoke or Fire checklist items. When he reached the step to close the cargo air shutoff valve, he stated that he had to "go in the back and do that."[10] During postaccident interviews, the flight engineer stated that, when he opened the door of the access panel to the cargo air shutoff valve, black smoke billowed out of the access panel.

At 2357:47, the first officer called for the Landing checklist. About 21 seconds later, the ATCT local controller stated, "just confirmed you are lined up for the left side it appears that you are lined up for the right." The first officer replied, "I thought we were cleared for the right . . . are we cleared to land on the right?" At 2358:16, the local controller replied, "you are cleared to land on the right we will just tell fire." The airplane landed on runway 27R about 2359.

Immediately after touchdown, the flight engineer reported smoke in the cockpit. After the airplane came to a stop, the first officer called for an emergency evacuation, and the captain and first officer conducted the Emergency Evacuation checklist. All of the flight crewmembers successfully evacuated the airplane using the emergency slide located at the left forward (L1) door. Section 1.15.1 discusses the flight crew's evacuation, and section 1.15.2 discusses the emergency response.

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[8] During postaccident interviews, the captain stated that, soon after the Lower Cargo Fire warning light illuminated, his electronic flight instrument system failed. He stated that, although there was power to the displays, no information was displayed.

[9] The PHL local controller did not tell the pilot that he had changed the landing runway assignment. FAA Order 7440.65, "Air Traffic Control," does not contain any specific rules or guidance to controllers regarding how to clearly communicate a change in runway assignment after an arriving aircraft has been cleared to land. See section 1.18.2 for information about a previously issued safety recommendation related to this issue.

[10] The cargo air shutoff valve is located on the right cabin wall just aft of the cockpit bulkhead.

1.2 Injuries to Persons

Table 1. Injury chart.

Injuries	Flight Crew	Cabin Crew	Passengers	Other	Total
Fatal	0	0	0	0	0
Serious	0	0	0	0	0
Minor	3	0	0	0	3
None	0	0	0	0	0
Total	3	0	0	0	3

Note: Title 14 CFR 830.2 states that a minor injury is any injury that does not qualify as a fatal or serious injury. The regulation defines a serious injury as any injury that (1) requires hospitalization for more than 48 hours, starting within 7 days from the date that the injury was received; (2) results in a fracture of any bone, except simple fractures of fingers, toes, or the nose; (3) causes severe hemorrhages or nerve, muscle, or tendon damage; (4) involves any internal organ; or (5) involves second- or third-degree burns or any burns affecting more than 5 percent of the body surface.

1.3 Damage to Airplane

The airplane was destroyed by fire after landing.

1.4 Other Damage

Most of the cargo on board the airplane was destroyed or damaged by fire.

1.5 Personnel Information

1.5.1 The Captain

The captain, age 59, was hired by UPS on September 19, 1988. He held a multiengine airline transport pilot (ATP) certificate, issued April 2, 1982, with a type rating in DC-8 airplanes. The captain held a first-class Federal Aviation Administration (FAA) airman medical certificate, dated February 3, 2006, with the limitation that he "must wear corrective lenses."

According to the captain, he worked as a charter pilot for Allegheny Commuter, Harrisburg, Pennsylvania, from September 1973 to June 1978. From July 1978 to November 1981, he worked as a first officer for several companies flying Convair, Learjet, and DC-8 airplanes. From December 1981 to September 1988, he worked as a first officer and captain flying DC-8 airplanes for Evergreen Airlines, McMinnville, Oregon.

UPS records indicated that the captain had accumulated about 25,000 total flight hours, including 16,000 hours as pilot-in-command (PIC) in DC-8 airplanes. He had flown about 41, 5 1/2, and 4 hours in the 90 days, 30 days, and 24 hours, respectively, before the accident flight. The captain's last line check occurred on July 21, 2005, and his last DC-8 series proficiency check and recurrent ground training occurred on September 8, 2005. A search of FAA records revealed no accident or incident history, enforcement action, or pilot certificate or rating failure or retest history. A search of the National Driver Register found no record of driver's license suspension or revocation.

According to the captain, when he was off duty, he typically went to bed between 0100 and 0200 and awoke about 0930. He stated that it was hard going back and forth between the night schedule that he kept when he was at work and the day schedule that he kept when he was at home. On February 4 and 5, 2006, he was off duty and engaged in routine activities and slept according to his off-duty night schedule. On February 6, he awoke about 0630 and later flew from his home in Orlando, Florida, to ATL to report for duty at 2115. He then flew from ATL to PHL with the accident flight crew and napped for about 1 1/2 hours in a recliner chair at the airport during cargo loading. He returned with the flight crew to ATL, slept in the hotel from about 0600 to 1200, and ate dinner about 1700 before reporting for the accident flight.

1.5.2 The First Officer

The first officer, age 40, was hired by UPS on February 19, 1996. He held a multiengine ATP certificate, issued January 4, 2006, with type ratings in British Aerospace BA-3100 and DC-8 series airplanes. The first officer held a first-class FAA airman medical certificate, dated February 1, 2006, with no limitations.

According to the first officer, he worked as a flight instructor for Acme School of Aeronautics, Fort Worth, Texas, from August 1988 to January 1990. From February 1990 to March 1991, he worked as a charter pilot flying BA-3100 airplanes for Alpha-Century Corporation in Fort Worth. From 1991 to 1995, he flew commuter flights in BA-3100 and Saab 340 airplanes for Express Airlines (now Pinnacle Airlines).

UPS records indicated that the first officer had accumulated 7,500 total flight hours, including 2,100 hours as second-in-command in DC-8 airplanes. He had flown about 5 1/2 and 4 hours in the 30 days and 24 hours, respectively, before the accident flight.[11] The first officer's last line check occurred on April 16, 1998, and his last DC-8 series proficiency check and recurrent ground training occurred on January 6, 2006. A search of FAA records revealed no accident or incident history, enforcement action, or pilot certificate or rating failure or retest history. A search of the National Driver Register found no record of driver's license suspension or revocation.

According to the first officer, when he was off duty, he typically went to bed about 0000 or 0100 and awoke about 0800 or 0900. On February 4, 2006, he engaged in routine activities at home in Crestwood, Kentucky, and went to bed about 2300. On February 5,

[11] The first officer did not fly in the 30 to 90 days before the accident flight.

he awoke about 0700, conducted routine activities at home, and went to bed about 2200. On February 6, he awoke between 0415 to 0430 to commute to ATL. He arrived at his hotel room, napped from about 1330 to 1800, exercised, skipped dinner, and got picked up at the hotel about 2110 for the flight to PHL. He stated that the first night of a trip sequence was normally the hardest for him because of the change to a night schedule. On February 7, he went to bed about 1000 and slept until 1200. Before reporting for the accident flight, he napped for a few hours in the afternoon, exercised, and skipped dinner.

1.5.3 The Flight Engineer

The flight engineer, age 61, was hired by UPS on January 24, 1994. He held a multiengine ATP certificate, issued March 29, 2002, with type ratings in Boeing 737, 757, and 767 airplanes. The flight engineer held a second-class FAA airman medical certificate, dated March 15, 2005, with no limitations.

The flight engineer stated that, from 1967 to 1989, he flew airplanes for the U.S. Air Force. He stated that he worked as a flight engineer on Boeing 747 airplanes for Trans World Airlines in 1990 and for America West Airlines from 1990 to 1992.[12]

UPS records indicated that the flight engineer had accumulated 9,000 total flight hours, including 2,000 hours as a flight engineer, 430 hours of which were in DC-8 airplanes. He had flown about 63, 43, and 4 hours in the 90 days, 30 days, and 24 hours, respectively, before the accident. The flight engineer's last line check occurred on April 17, 2004, and his last DC-8 series proficiency check and recurrent ground training occurred on June 4, 2005. A search of FAA records revealed no accident or incident history, enforcement action, or pilot certificate or rating failure or retest history. A search of the National Driver Register found no record of driver's license suspension or revocation.

According to the flight engineer, when he was off duty, he typically went to bed about 2200 and awoke about 0630. On February 4, 2006, he engaged in routine activities at home in Tucson, Arizona, and went to bed about 2200. On February 5, he awoke about 0700, worked around the house, and went to bed about 2130. On February 6, he awoke about 0500, flew to ATL, napped in the hotel from 1500 to 1730, ate dinner, and returned to the airport about 2100. On February 7, he flew to PHL about 2100 and then returned to ATL about 0520. He slept from about 0600 to 1100, and, later that day, napped from 1600 to 1800, ate dinner, and reported to ATL about 2100. He indicated that this was his normal layover routine and that he felt rested.

[12] From December 1992 to January 1993, the flight engineer was a flight test analyst for the Air Force National Guard, and he did not fly aircraft during this time.

1.6 Airplane Information

The accident airplane was manufactured as a convertible freighter by McDonnell Douglas in December 1967.[13] UPS bought the airplane in 1985, and the airplane was in a cargo configuration at that time. Interstate Airlines operated the airplane for UPS until July 2, 1988, at which time UPS took over operation of the airplane.

At the time of the accident, the airplane had accumulated about 67,675 total flight hours. The airplane was equipped with four CFM International CFM56 engines. According to the load manifest for the accident airplane, the airplane's estimated landing weight was about 229,586 pounds, including 36,300 pounds of fuel and 58,312 pounds of baggage and cargo, which was within the landing weight limit of 258,000 pounds.

1.6.1 Airplane Configuration

The airplane was configured with three flight crew seats and two observer seats in the cockpit and two seats across from the L1 door. The airplane had a main cargo compartment, which was configured to accommodate 18 cargo containers, and 4 lower cargo compartments. (See figure 1 for a diagram of the airplane's cargo configuration.) A smoke curtain, which had cargo netting behind it, was located between the forward crew galley and the cargo area to maintain a smoke barrier. A closable opening in the smoke curtain provided access to the cargo area; however, with the cargo containers in place, no room is available to walk aft into the cargo area.[14]

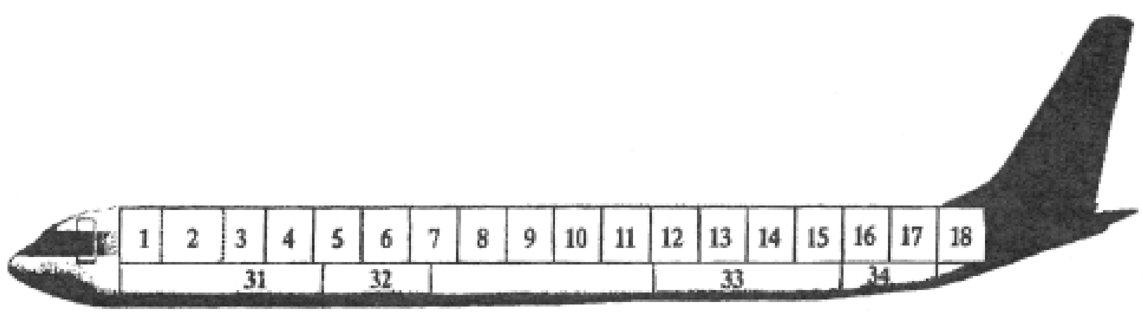

Figure 1. Diagram of the airplane's cargo configuration.

The airplane had eight floor level doors (L1 to L4 on the left side of the airplane and R1 to R4 on the right side of the airplane) and four overwing hatches. (See figure 2 for

[13] The airplane was and remains certificated under *Civil Aviation Regulations* (CAR) 4b. The CARs were recodified in 1965 as Part 25 of the *Federal Aviation Regulations.*

[14] To gain access to the cargo area, it is also necessary to remove or move aside the cargo netting.

a diagram of the airplane's doors and exits.) Five of the floor level doors (L2, L3, R1, R2, and R3) and the two aft overwing hatches had been deactivated such that they could not be opened from the outside. The L1, L4, and R4 doors, the two forward overwing hatches, and the two cockpit windows (designated as emergency exits) were operable from the outside. The airplane had four lower cargo compartment doors located on the right side of the airplane (two forward of the wing and two aft of the wing) and a main cargo door located on the left forward fuselage. Section 1.6.1.2 discusses the airplane's main cargo door in more detail.

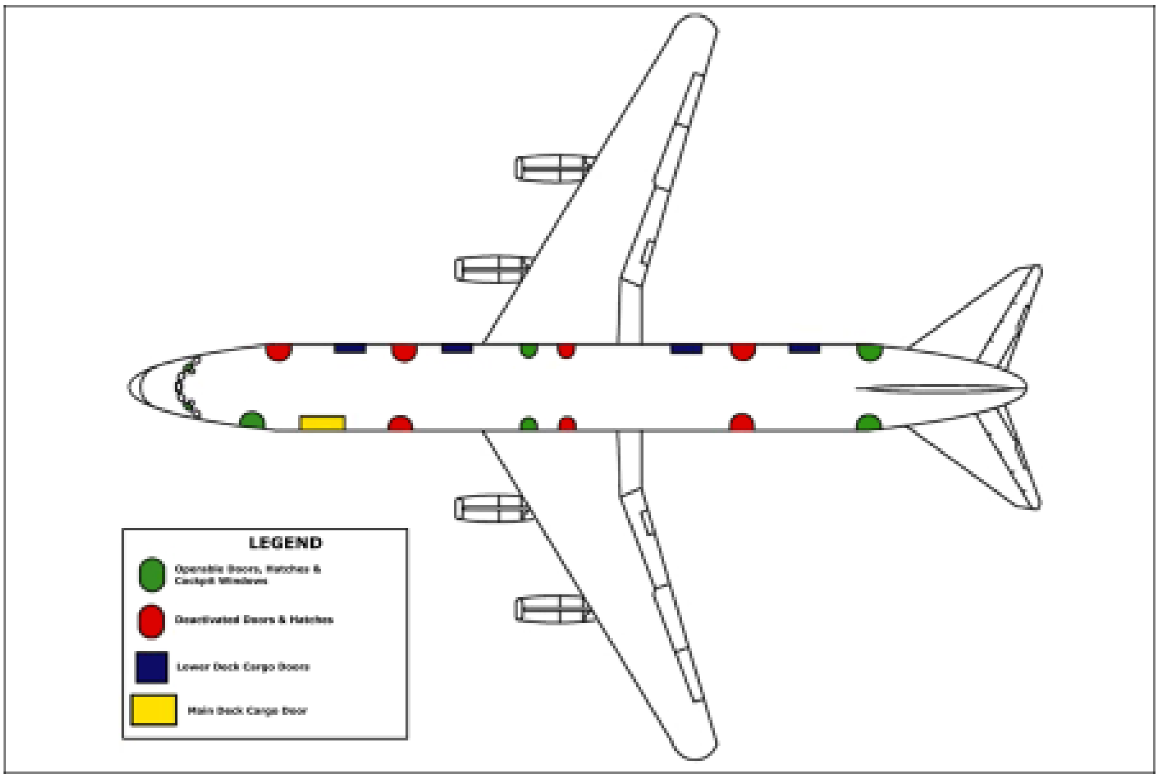

Figure 2. Diagram of the airplane's doors and exits.

1.6.1.1 Emergency Exits

In accordance with *Civil Aviation Regulations* (CAR) 4b, the accident airplane was required to have two emergency exits, one on each side of the airplane. Two of the airplane's cockpit windows (one on each side of the cockpit) were designated as "emergency exits" in the UPS DC-8 Aircraft Operating Manual (AOM) and on the emergency briefing card and were operable from both inside and outside the airplane. CAR 4b also stated, "all emergency exits and their means of opening shall be marked on the outside of the airplane for guidance of rescue personnel."[15] Each cockpit window exit had two exterior placards that provided instructions for its operation.

[15] Passenger airplanes certified after June 7, 1965, are required under 14 CFR 25.811(f) to have a 2-inch contrasting colored band outlining emergency exits in addition to exterior markings providing instructions on their operation. Cargo airplanes are not required to have such bands around the emergency exits.

The L1 door, which was the entry and exit door for crewmembers during normal operations, was also designated as an "emergency exit" in the UPS DC-8 AOM and on the emergency briefing card. According to the FAA, operators often designate the L1 door (with slide installed) as an alternate emergency exit. Further, the pilot's Emergency Evacuation checklist stated, "All crewmembers and ACMs [additional crewmembers] evacuate through the cockpit window exits or forward cabin door [L1]." Although the interior of the L1 door included instructions for emergency door operation, the door did not have exterior operational placards.

1.6.1.2 Main Cargo Door

The main cargo door is held in place by latches, which are, in turn, held in place by lockpins. A small vent door, which prevents the main cargo door from being opened while the airplane is still pressurized, is located on the aft portion of the cargo door and is mechanically linked to the lockpin mechanism. The vent door is designed so that it cannot be closed unless the cargo door is closed, latched, and locked; similarly, the cargo door cannot be opened until the vent door is opened. Opening the vent door moves the lockpins clear of the latches, allowing them to be rotated to the unlatched position. The door is then hydraulically opened.

Normal operation of the vent door, like operation on all UPS DC-8s, is accomplished by activating an electrical switch on the interior wall adjacent to the L1 door entryway.[16] Once the vent door has been opened, another switch under the floor panel near the L1 door entryway is then placed into the ON position to energize the hydraulic pump that operates the cargo door. Manual movement of the door's control valve, which is adjacent to the hydraulic pump switch, to the OPEN position hydraulically opens the door's lockpin and latch mechanisms and begins raising the cargo door.

Manual operation of the main cargo door, which is used when airplane or auxiliary power is not available, requires that the vent door be opened by manually rotating the exterior handle located above the vent door. At this point, the cargo door can be unlocked and unlatched by either manually operating the door's hydraulic pump inside the airplane or by manipulating the lockpin and latch mechanisms on the exterior of the door. This latter method requires that the latch fitting be rotated to the OPEN position while the lockpin lever is held in the unlocked position. Once the latch fitting is rotated to the OPEN position, the door can be manually raised. Regardless of the method used for unlocking and unlatching, the door can be raised by continuous manual operation of the hydraulic pump or by use of a sling or other mechanical means.

1.6.2 Smoke and Fire Detection and Warning System

The airplane was equipped with a smoke and fire detection and warning system to provide flight crews with a visual indication in the cockpit of smoke or fire in the

[16] UPS modified its DC-8s to allow the vent door to be electrically opened and closed. Originally, operation of the vent door required manual movement of a handle on the exterior of the door.

cargo compartments. The airplane had 7 smoke detectors installed in the main cargo compartment, and 19 smoke detectors installed in the 4 lower cargo compartments.

The flight crew tested the operation of the smoke detectors by enabling their test function from the cockpit during the preflight check. The flight engineer reported that no problems were encountered during the functional check of the smoke detectors before the accident flight.

1.6.2.1 Main Cargo Compartment Smoke Detectors

The main cargo compartment smoke detector system, which was installed at the time of the airplane's manufacture, comprised detectors located in the compartment ceiling that were designed to provide a smoke indication whenever the smoke around a detector reached a certain density (80 to 90 percent of normal light transmission). Five of the seven smoke detectors were mounted on the left side of the ceiling at locations corresponding to cargo containers 2, 5, 8, 11/12, and 14. The other two detectors were mounted next to each other near the ceiling centerline at locations corresponding to cargo containers 17 and 18. (See figure 1.)

The smoke detector switch, which is located on the flight engineer's upper panel, provides a means for testing the smoke detectors and the system wiring. The smoke detector switch has the following labeled positions: OFF, NOR [normal], and 1 through 7. Positions 1 through 7 are used during preflight to test the integrity of the alerting circuit for each detector;[17] however, the system is not able to identify the specific sensor(s) detecting smoke in the event of an actual alert. The smoke detector system is operational as long as the smoke detector switch is not in the OFF position, and a cockpit smoke indication will be triggered whenever smoke at any of the seven detectors is sensed.[18] When smoke is detected, the amber Cargo Smoke light on the flight engineer's panel is illuminated.

The main cargo smoke detectors on the accident airplane were all damaged or destroyed by fire, and no postaccident functional testing was possible.

1.6.2.2 Lower Cargo Compartment Smoke and Fire Detectors

On March 30, 2001, to comply with 14 CFR 121.314,[19] the 19 lower cargo compartment smoke detectors were installed on the airplane: 6 in the forward compartment, 4 in the forward middle compartment, 5 in the aft middle compartment, and 4 in the aft compartment.

The smoke detection system for the lower cargo compartments has a control display unit (CDU), located in the cockpit to the right of the flight engineer's station, which displays system status information and alarms to the flight crew. The CDU receives

[17] Flight crew preflight procedures include testing each of the main cargo smoke detector circuits by rotating the switch and noting illumination of the test light.

[18] The smoke detector switch was found in the NOR position post accident.

[19] As of March 19, 2001, 14 CFR 121.314 specified that cargo compartments such as the lower compartments on the accident airplane were required to be equipped with a smoke or fire detection system.

inputs from a central control unit that monitors signals from the 19 detectors. When the control unit receives signals (either smoke or smoke and temperature more than 150° Fahrenheit)[20] from two detectors in the same compartment, the CDU illuminates the Lower Cargo Fire and Master Warning lights and indicates the compartment in which the smoke/fire was detected.

Examination of the smoke detection system components for the lower cargo compartments revealed that the smoke/fire alert that activated in the cockpit during the flight was initially triggered by detectors in the aft middle compartment, which is located below main cargo containers 12 to 15, and that the detectors subsequently registered smoke in the aft cargo compartment. Postaccident tests of the smoke detection system revealed no anomalies.

1.6.2.3 Certification Requirements for Smoke and Fire Detection Systems

At the time that the DC-8 was certified, regulations did not specify the time frame for smoke detection; however, an FAA letter to Boeing dated March 12, 1965, stated the following:

> the maximum smoke detection time to demonstrate compliance with the regulations for any class of cargo compartment is five (5) minutes. The time is measured from the initiation of smoke generation until the time that an acceptable indication is available to the crew.

A review of the manufacturer's records indicated that the DC-8 certification tests used smoke generators that were ignited and placed in a vented steel box, which was placed at a determined critical location,[21] and the smoke light located in the cockpit was monitored. During the tests, the detection times varied from 12 seconds to 3 minutes. The cargo compartment was empty during these tests. According to the FAA, cargo compartment smoke detection certification tests are typically conducted with no cargo containers in the cargo compartments and with the smoke-generating device in the open area of the cargo compartment, located at a point farthest from any smoke detectors. Boeing also indicated that cargo compartment smoke detector certification tests were conducted without cargo containers in place and that this was an industrywide practice.

In 1980, the FAA adopted 14 CFR 25.858,[22] which contained more explicit performance objectives, including the following:

> a) The detection system must provide a visual indication to the flight crew within 1 minute after the start of the fire.

[20] The control unit provides an alarm condition when smoke indications or smoke and high temperature indications are received from two different detectors within the same compartment.

[21] The critical location is a position located farthest from any of the smoke and fire detectors and is intended to provide the most challenging position for the tests.

[22] See section 1.18.4 for information on Advisory Circular 25-9A, which provided guidance on how operators could conduct certification tests to meet compliance with 14 CFR 25.858.

b) The system must be capable of detecting a fire at a temperature significantly below that at which the structural integrity of the airplane is substantially decreased.

c) There must be means to allow the crew to check in flight the functioning of each fire detector circuit.

d) The effectiveness of the detection system must be shown for all approved operating configurations and conditions.

However, 14 CFR 25.858 only applied to newly certificated aircraft, allowing previously certificated smoke detection systems, including the one installed on the accident airplane, to maintain the 5-minute detection time limit specified in the FAA's March 1965 letter.

1.6.3 Air Conditioning and Pressurization System

The airplane's air conditioning and pressurization system distributed air for cooling and heating the airplane's cockpit and cargo areas. The airplane is pressurized by the air entering the cabin and cockpit from the air conditioning packs. Proper cabin pressure is maintained by controlling the amount of air exhausted overboard through the outflow valves, which are located in the rear of the airplane and can be controlled automatically or manually. One electrically driven recirculation fan is installed in the forward accessory compartment to recirculate the cabin and cockpit air. The recirculation fan can be operated independently or along with one or both of the air conditioning packs.

The system has one main duct through which cabin supply air is routed. The main duct is located behind the cargo liner and runs the length of the main cargo compartment along the centerline of the ceiling. The main duct has supply ducts on either side of it, which provide outlets for the conditioned air.

1.7 Meteorological Information

Weather observations at PHL are made by an automated surface observing system (ASOS). The ASOS records continuous information on wind speed and direction, cloud cover, temperature, precipitation, and visibility and transmits an official meteorological aerodrome report (known as a METAR) each hour. The 2354 METAR indicated the following: wind 270° at 7 knots, visibility 10 statute miles (sm), clear sky, and temperature 0° Celsius (C). The 0054 METAR on February 8, 2006, indicated the following: wind 300° at 8 knots, visibility 10 sm, clear sky, and temperature -1° C.

1.8 Aids to Navigation

No problems with any navigational aids were reported.

1.9 Communications

No communications difficulties between the pilots and any of the air traffic controllers who handled the accident flight were reported.

1.10 Airport Information

PHL is located about 5 miles southwest of downtown Philadelphia at an elevation of about 36 feet. The airport has one set of parallel runways, 9L/27R and 9R/27L, and two nonparallel runways, 8/26 and 17/35. The airport has 24-hour ATCT service.

1.10.1 Aircraft Rescue and Firefighting Information

PHL has an FAA-approved airport emergency plan (AEP), which requires the airport to respond to all on-site accidents, and maintains a 14 CFR Part 139 Index E[23] aircraft rescue and firefighting (ARFF) facility, which is operated by the City of Philadelphia, on the airfield. The PHL ATCT has a crash phone, which serves as a direct phone link and activates a buzzer and lights at the ARFF facility, the airport communications center, and the city fire dispatcher at the fire communication center. The ARFF facility provides services for the airport 24 hours a day, 7 days a week. A minimum of 13 ARFF personnel is present at the facility at all times.

1.10.1.1 Aircraft Rescue and Firefighting Training

In accordance with 14 CFR 139.319(i), each holder of an airport operating certificate must ensure that ARFF personnel are properly trained to perform their duties. ARFF personnel are required to receive initial training and participate in at least one live-fire drill before initially performing ARFF duties and in recurrent training and drills every 12 months thereafter. Further, the curriculum for initial and recurrent training must include at least the following subject areas:

- airport familiarization, including airport signs, marking, and lighting;
- aircraft familiarization;
- ARFF personnel safety;

[23] Part 139 establishes minimum standards for aircraft rescue and firefighting (ARFF) equipment based on the number, frequency, and size of passenger-carrying aircraft that use the airport. Index E refers to ARFF requirements for airports used by air carrier aircraft of at least 200 feet in length.

- emergency communications systems on the airport, including fire alarms;
- use of the fire hoses, nozzles, turrets, and other required appliances;
- application of types of required extinguishing agents;
- emergency aircraft evacuation assistance;
- firefighting operations;
- adaptation and use of structural rescue and firefighting equipment for ARFF;
- aircraft cargo hazards, including hazardous materials/dangerous goods (DG) incidents; and
- familiarization with firefighters' duties under the AEP.

According to the PHL ARFF training officer, the facility had no formal training syllabus or curriculum for its in-house training. He stated that, for its in-house training, the facility used PowerPoint presentations from other airports' training curricula, an FAA ARFF training compact disc (CD), and a Specialized Aircraft Fire Training (SAFT) mockup, which is shaped like a Boeing 737.

1.10.1.2 Aircraft Familiarization Training and Equipment Use Training

FAA Advisory Circular (AC) 150/5210-17A, "Programs for Training of Aircraft Rescue and Firefighting Personnel," dated April 28, 2006, provides guidance on how to meet the provisions of 14 CFR 139.139(i) and details on what should be included in the training program for each of the FAA-required subject areas.

Regarding aircraft familiarization training, AC 150/5210-17A recommends that ARFF personnel be trained such that they are able to "identify the types of aircraft operating at the airport . . . [and] locate normal entry doors, emergency exit openings, and evacuation slides for a given aircraft." According to a captain at the PHL ARFF facility, at the time of the accident, ARFF personnel received passenger aircraft familiarization training. However, PHL did not schedule cargo aircraft familiarization training, including training on the operation of the doors of the aircraft used by UPS, for the other cargo operators who operate at the airport; these operators include Federal Express Corporation (FedEx), DHL, and BAX Global. PHL ARFF personnel experienced problems opening the main cargo door during the emergency response.

Regarding training on ARFF equipment use, AC 150/5210-17A states that ARFF personnel should be able to "identify the proper procedures for use and maintenance of each hose, nozzle, and adapter used locally." AC 150/5220-10C, "Guide Specification for Water/Foam Aircraft Rescue and Firefighting Vehicles," dated February 18, 2002, also addresses equipment training. However, neither AC specifically addresses the use of a high-reach extendable turret with skin-penetrating nozzle (HRET/SPN).[24]

In 2005, the FAA conducted research to evaluate and compare the ability of ARFF vehicles to extinguish a fire using a roof turret and handlines or an HRET/SPN. In its final report on this research, the FAA concluded that, in all aspects of the evaluation, the HRET/SPN outperformed the standard roof-mounted turret and handline, including the ability to control and contain the spread of interior fire and reduce high cabin temperatures.[25] In its *Aircraft Rescue and Fire Fighting Computer-Based Training* CD,[26] the FAA indicated that the "successful use of elevating waterways and aircraft skin penetrating nozzles is dependent on the skill level and dexterity of the operator." Additionally, the International Fire Service Training Association's (IFSTA) textbook, *Aircraft Rescue and Fire Fighting,*[27] states that HRET/SPNs are complicated devices to operate and that drivers and operators will require continual training in their operations, tactics, and strategies.

Interviews with an HRET/SPN manufacturer revealed that it has developed a computer-based training simulator program that uses an HRET/SPN joystick and foot-pedal mockup. According to the manufacturer, this training program is "self-teaching" and allows beginner students or advanced operators to practice the skills needed to successfully operate the HRET/SPN and to progress and test skills at their own pace. According to the manufacturer, it has delivered about 150 HRET/SPNs to U.S. airports, and 11 of these airports, not including PHL, have the training simulator.

The PHL ARFF facility obtained an HRET/SPN in 1991. At the time of the accident, the facility had a small general aviation airplane that ARFF personnel used to practice penetrating the fuselage with the HRET/SPN. The facility currently uses a SAFT, which is designed to allow a piece of sheet metal to be inserted into its side, for piercing practice. PHL ARFF did not routinely practice hands-on HRET/SPN piercing skills. PHL ARFF personnel used an HRET/SPN during the emergency response for this accident and experienced some difficulties with its use. Section 1.15.2 discusses the problems PHL ARFF personnel had trying to open the main cargo door and using the HRET/SPN during the emergency response.

1.10.1.3 Postaccident Aircraft Rescue and Firefighting Training Changes

After the accident, PHL ARFF personnel began conducting cargo aircraft familiarization training, which included procedures on the manual operation of the

[24] An HRET/SPN is a piece of equipment that can be attached to some ARFF vehicles to improve firefighting capabilities inside aircraft. The device consists of an elevated extendable boom and a multifunction nozzle/turret, which can be equipped with options such as piercing tips of varying lengths, aerial nozzles, halogen lights, a color video camera, and a forward-looking infrared camera.

[25] U.S. Department of Transportation, Federal Aviation Administration, *High-Reach Extendable Turrets with Skin-Penetrating Nozzle*, DOT/AR-05/53 (Washington, DC: FAA, 2005).

[26] U.S. Department of Transportation, Federal Aviation Administration, *ARFF: Aircraft Rescue and Fire Fighting Computer-Based Training,* Version 1.0 (Washington, DC: FAA, 2002).

[27] International Fire Service Training Association, *Aircraft Rescue and Fire Fighting,* 4th Edition (Still Water, Oklahoma: IFSTA, 2001).

main cargo door, at UPS and the other cargo operators at PHL. All ARFF personnel have completed the aircraft familiarization training on the aircraft operated by UPS and are conducting familiarization training with the other cargo operators at PHL as airplanes become available (for example, during layovers or overnight parking). PHL training records have been modified to show when the training has been completed. According to the PHL ARFF training officer, cargo aircraft familiarization training will be continued as part of PHL's initial and annual training for all ARFF personnel.

In addition, UPS provided PHL ARFF with Emergency Rescue Response diagrams, which provide information on the locations and operation of exits and doors, including the cargo compartment doors, for all of the airplanes it operates out of PHL, including the DC-8. Since the accident, these diagrams have also been uploaded to a laptop computer carried in the PHL command vehicle.

However, a review of the DC-8 diagrams by National Transportation Safety Board investigators revealed that they did not accurately depict the DC-8 accident airplane. For example, a general note on one of the diagrams states that there is a "2-inch wide band of contrasting color indicating all doors, hatches and windows [are] externally operable." However, the airplane did not have the 2-inch contrasting color band. Further the diagram showed the deactivated aft overwing hatches as "externally operable," and the diagram providing guidance on the operation of the main cargo door does not mention that the vent door must be opened before any of the listed steps can be successfully performed.

1.11 Flight Recorders

1.11.1 Cockpit Voice Recorder

The accident airplane was equipped with a Fairchild Model A-100 CVR. The CVR was sent to the Safety Board's laboratory in Washington, D.C., for readout and evaluation. The exterior of the CVR exhibited heat damage, but the interior was undamaged. The tape was played back normally and without difficulty. The recording consisted of four separate channels: the captain, first officer, and second officer audio panels and the cockpit area microphone (CAM). The captain and first officer audio panels provided fair quality audio information, and the CAM and second officer audio panels provided good quality audio information.[28] A transcript was prepared of the entire 31-minute, 17-second recording (see appendix B).

1.11.2 Flight Data Recorder

The accident airplane was equipped with a solid-state L3 Communications Fairchild model F-1000 flight data recorder (FDR). The exterior of the FDR exhibited smoke and

[28] The Safety Board rates the quality of CVR recordings according to a five-category scale: excellent, good, fair, poor, and unusable. See appendix B for a description of these ratings.

heat damage, but the interior was undamaged. The FDR was sent to the Safety Board's laboratory for readout and evaluation. The FDR recorded data for the entire accident flight. Seventeen parameters were recorded by the FDR. Throughout the last 2 minutes 17 seconds of the flight, data for 12 of the parameters became unreliable.

1.12 Wreckage and Impact Information

No impact occurred during the landing of the airplane. All of the airplane and cargo damage resulted from the fire, and this damage is discussed in section 1.14.

1.13 Medical and Pathological Information

Specimens were obtained from the captain, first officer, and flight engineer and were tested by UPS. The specimens tested negative for alcohol and drugs of abuse.[29]

1.14 Fire

Examination of the airplane's wiring revealed no fused wires, metal balls (beading) on the ends of broken wires, or other indications consistent with an electrical short circuit or fire initiation.

1.14.1 Fire Damage to Exterior Fuselage

The fuselage had two complete burnthrough holes in the crown (located over cargo containers 12, 13, and 14 and 15 and 16) and two areas of partial burnthrough (located at cargo containers 12 and 17)[30] on the right side of the airplane aft of the wing. (See figure 3 for a photograph showing the fire damage to the fuselage.) Except for the areas around the two complete burnthrough holes, the exterior paint was mostly present. The area around the forward entrance door, the four overwing hatches, and the right aft service door was sooted. The paint around the main outflow valve was heavily sooted and lightly bubbled. No other significant exterior damage to the airplane was noted.

[29] In accordance with the requirements of the National Institute for Drug Abuse, the drugs tested for by UPS included marijuana, cocaine, opiates, phencyclidine, and amphetamines.

[30] A complete burnthrough means that large portions of fuselage material are missing and significant structural damage has occurred. A partial burnthrough means that the fuselage skin has ruptured but that little structural damage has occurred.

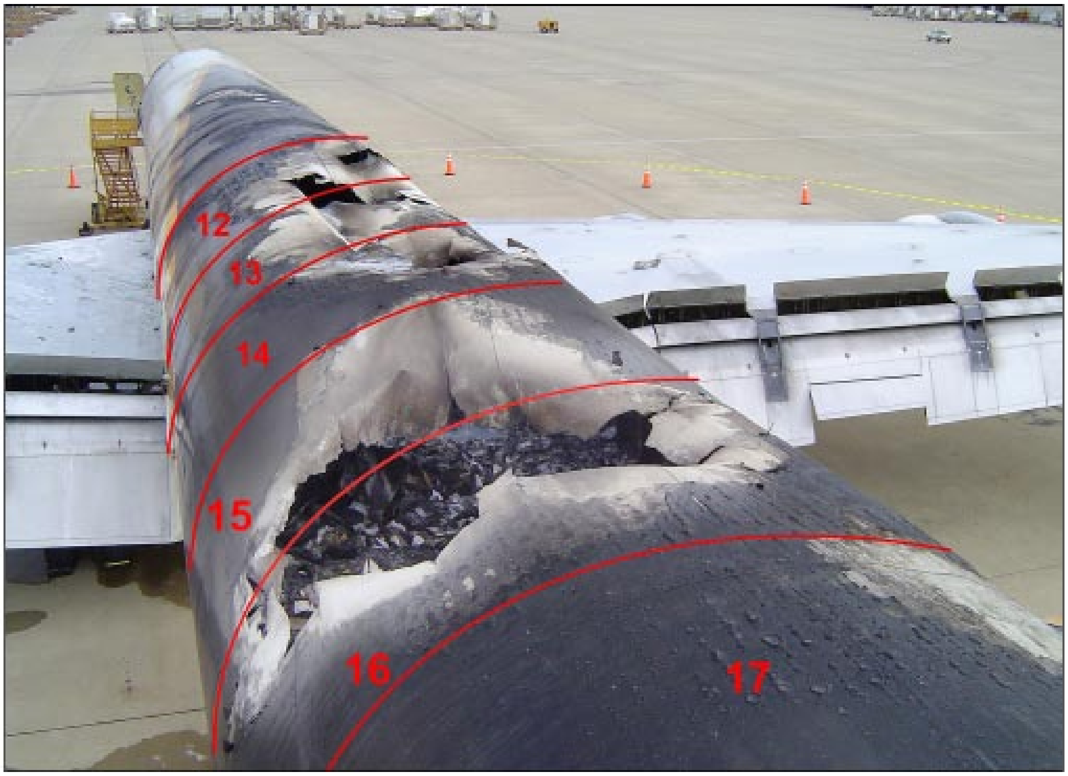

Figure 3. Damage to the fuselage crown.

1.14.2 Fire Damage to Lower Cargo Compartments

No smoke or heat damage was observed inside the lower cargo compartments. Areas behind the cargo liners were also examined, and no signs of soot or thermal damage were found in compartments 31, 32, or 34. Some of the structure behind the sides of the cargo liner in compartment 33 was sooted, and examinations of the soot deposits revealed progressively heavier sooting toward the front end of the compartment and lighter sooting toward the aft end. Melted aluminum and Lexan material (a heavy-duty plastic used for the cargo container walls), which had dripped down through the floor vents above the container, had also adhered to some of the structure behind the liner. The entire underside of the ceiling above compartment 33 exhibited soot. No discernible smoke patterns were found.

1.14.3 Fire Damage to Fuselage Interior and Main Cargo Compartment

The main cargo compartment forward of container 8 was heavily sooted but structurally intact. Progressively more fire damage to the cargo compartment was documented moving aft from container positions 8 to 12. Upper portions of most of the fuselage frames from near the middle of cargo container 8 to the middle of container 12 had been consumed by fire, and the upper structure was sagging in several areas above containers 9, 10, and 11. None of the individual container floors or the main cargo compartment floor exhibited fire damage. (See figure 1.)

Fuselage structure above cargo containers 12 to 14 exhibited severe thermal damage. Fire had consumed the upper portions of the fuselage frames above the forward section of container 12, and the skin was sagging in these areas. Severe thermal damage to the right fuselage adjacent to container 12 extended down to the floor and included a small burnthrough of the skin located near the bottom of the window. Most of the upper frame structure and a portion of the fuselage crown above containers 12 and 13 had been destroyed by fire. The fuselage crown had been burned through, and several of the upper frames had been destroyed in the areas above container 13 and the forward portion of container 14.

A large area of the fuselage crown over the aft portion of container 15 and the forward portion of container 16 had been consumed by fire, and the fuselage skin was sagging around the perimeter of the burned area. The area of the burnthrough extended down to just above the windows on the left side of the fuselage. Thermal damage to the fuselage extended from the crown to the windows on the right side of the fuselage, adjacent to container 17, and included a small burnthrough of the fuselage skin.

1.14.4 Fire Damage to Main Cargo Compartment Containers and Contents

Main cargo compartment containers 1 to 17 were similar in size and construction and comprised an aluminum floor, frame, and roof and Lexan walls. Cargo position 18 consisted of a flat aluminum cargo sheet. The container contents, except for those in containers 15 and 18, primarily consisted of shipments packaged in cardboard boxes. Cargo container 15 was loaded with a large shipment of bulk paper, and container 18 was loaded with boxed spools of extruded thread on top of which hydraulic valves were placed, all of which were wrapped with shrink-wrap.

Fire damage to the cargo containers varied from the forward-most containers, which exhibited minor sooting, to the containers adjacent to and aft of the wings, which exhibited the most severe thermal damage and consumed material. The severity of the fire damage to the cargo containers was greatest to those containers starting just aft of the overwing hatches, from cargo containers 8 and 9, to the aft end of the main cargo compartment, aft of cargo container 18. Examinations revealed that the heaviest fire damage to the interior and the cargo container contents occurred between cargo containers 12 and 17 and that the lowest point of fire damage to the fuselage occurred on the right side of the airplane near cargo container 12. Table 2 summarizes the damage to each of the main cargo containers, liners, and contents.

Numerous items were removed from the main cargo compartment and sent to the Safety Board's Materials Laboratory in Washington, D.C., for further examination. See section 1.16.1 for more information about these items and the laboratory examinations.

Table 2. Summary of damage to main cargo containers, liners, and contents.

Container Number	Fire Damage to Container and Liners	Fire Damage to Container Contents
1	The container was intact. The roof, upper portion of the curtain, and the ceiling liner were sooted. The curtain is located between the two front walls.	No fire damage was observed.
2	The container was intact. The roof, upper portion of the curtain, and the ceiling liner were sooted.	No fire damage was observed.
3	The forward wall was warped along the top, and the roof was sagging. The ceiling liner was sooted.	No fire damage was observed.
4	The upper portions of the forward wall were sagging. The aft wall was melted along the top and was sagging to midheight. The roof was sooted and sagging. The ceiling liner was sooted.	The container was empty.
5	The forward wall was sagging, and other walls were heavily sooted. The roof was heavily sooted and sagging. The ceiling liner was sooted.	No fire damage was observed.
6	The forward and aft walls were melted and sagging down to midheight. The container frame was intact. The right side of the ceiling liner was sooted.	Smoke damage to the contents was observed. Several packages in the aft portion of the container were singed.
7	The forward and aft walls were melted down to midheight. The roof was burned through. The upper halves of both sidewalls were sooted. The aft portion of the ceiling liner was hanging down.	Smoke damage to the contents was observed. The contents were not damaged by fire because they only filled the container to midheight.
8	Portions of the forward wall were melted or consumed by fire. The roof was melted. The aft panels were consumed by fire, except for a small portion in the aft left corner. The ceiling liner was consumed by fire.	Fire damage, mainly to the exposed tops and sides of some of the contents, was observed.
9	Most of the forward wall and roof were consumed by fire. The aft panels were consumed by fire, except for a small portion in the center of the panel near the floor. The ceiling liner was consumed by fire.	The contents on the left side of the container exhibited the most damage, extending to a depth of about 12 to 18 inches. In the lesser-damaged areas, the damage only extended to midheight.
10	The roof, walls, and framing were consumed by fire down to midheight. The ceiling was consumed by fire.	The contents on the right side of the container exhibited the most fire damage. Fire damage to the contents extended to a depth of about 12 to 18 inches at the lowest level of damage.
11	Most of the container was destroyed by fire. The floor was intact. The ceiling was consumed by fire.	The contents in the aft portion of the container exhibited the most fire damage. The damage to the contents extended to a depth of about 12 inches at the lowest level of damage.

Container Number	Fire Damage to Container and Liners	Fire Damage to Container Contents
12	Most of the container walls and roof were destroyed by fire, except in the aft left corner. The floor was intact. The ceiling liner was consumed by fire.	The fire damage was heaviest around the edges of the container and between the right forward corner and center of container. Fire damage to the center contents extended to a depth of about 18 to 24 inches, and the rest of the contents were damaged down to the floor of the container.
13	The lower left wall remained intact but was melted down to midheight. The roof was destroyed, except for the aft left corner. The rest of the container walls were consumed by fire, and the remaining framing was burned down to midheight. The ceiling was consumed by fire.	Fire damage to the contents extended to a depth of about 12 inches in the right forward corner and to midheight in the aft left corner.
14	The left wall and the door were melted down to midheight. The rest of the container and the ceiling liner were consumed by fire.	Fire damage to the contents in the right aft corner extended to a depth of about 12 inches. The remaining contents exhibited less fire damage.
15	The roof and most of the walls were consumed by fire. The framing was melted down past midheight. The ceiling liner was consumed by fire.	Most of the contents were intact. Some fire damage to the exposed outer surfaces was observed.
16	The roof, most of the walls, and the ceiling lining were consumed by fire.	Fire damage to all of the contents extended to a depth of about 12 inches.
17	The upper half of the aft wall was melted and sagging. The roof was consumed by fire, except for the aft left corner. The ceiling was consumed by fire.	The contents near the front and sides of the container exhibited the heaviest damage, and the damage extended to a depth of about 12 inches. The damage to the contents lessened toward the middle of the container.
18	The pallet was intact and exhibited no smoke or fire damage. The ceiling liner was consumed by fire.	Some of the contents were destroyed by fire. Fire damage to the remaining contents extended to a depth of about 12 inches.

1.15 Survival Aspects

1.15.1 Emergency Evacuation

After the airplane landed and stopped, the flight crew conducted the Emergency Evacuation checklist and then proceeded to evacuate the airplane. During postaccident interviews, the flight engineer stated that he took a breath of oxygen from his mask before evacuating and that he then went to open the L1 door. He stated that he reached down and deployed the L1 door slide and evacuated using the slide and that he then yelled back to the other flight crewmembers that the slide was "good."

The first officer stated that he leaned out his window to get fresh air but that he inhaled smoke. The first officer stated that, after he transmitted to the ATCT that they were evacuating the airplane, the smoke was so heavy that he could not see his hand in front of him. He stated that he grabbed his flashlight and reached behind the captain's seat for the notice to captain (NOTOC),[31] which is typically contained in an air DG envelope behind the captain's seat, but could not locate it. He proceeded to evacuate using the L1 door slide while black smoke was rolling out of the door. He stated that, after he evacuated the airplane, he could see black smoke billowing out of the windows and the door but that there were neither flames nor heat.

The captain stated that, after the airplane came to a stop, he heard the L1 door slide deploy. He stated that he reached behind him, grabbed the escape rope, opened the window, and threw the rope through the window. He stated that, although he had initially planned on using the escape rope to evacuate the airplane, he decided to use the L1 slide because he wanted to make sure that the first officer got out of the airplane. The captain stated that he searched around behind his seat but was unable to locate the NOTOC.

The captain stated that he became concerned about whether the first officer had exited the airplane, so he then headed toward the galley area behind the cockpit. He stated that he did not see the first officer and evacuated the airplane via the L1 door slide. The captain stated that the ARFF vehicles were waiting when he evacuated the airplane and that he informed ARFF personnel that there were hazardous materials on board and that he had not been able to locate the NOTOC. After the three flight crewmembers safely evacuated the airplane, they were transported to a local hospital and treated for smoke inhalation.

1.15.2 Emergency Response

Immediately after being notified by the captain of the cargo smoke indication, the tower controller activated the crash phone to announce an Alert 1[32] to the PHL Airport Operations Center, the PHL ARFF facility, and the Philadelphia Fire Department. Originally, the ARFF vehicles were headed to the standby positions for runway 27L; however, the change in landing runways (from 27L to 27R) resulted in a subsequent change in standby positions. ARFF personnel reported that the change in runways resulted in a 60- to 90-second delay in responding to the accident scene. Seven PHL ARFF vehicles responded.

According to postaccident interviews with ARFF personnel, the airplane came to a complete stop on runway 27R as the ARFF units approached. They reported that no fire was visible at that point but that smoke could be seen emanating from the open L1 door and the outflow vent in the tail.

[31] Title 49 CFR 175.33 requires operators to provide the PIC with certain information about hazardous materials on board the flight, in writing, before departure. UPS satisfies this requirement through the use of a NOTOC, which contains the shipping documentation describing the hazardous materials on the airplane, including the customer-prepared shipping papers that accompany each hazardous materials package. The shipping papers include, in part, a shipping description, package reference and UPS account number, label information, and shipper's certification. For more information about UPS' on-board hazardous materials procedures, see section 1.17.2.

[32] According to the PHL Airport Certification Manual, an Alert 1 indicates a reported aircraft emergency or problem (for example, a hydraulic failure or bad gear indication).

After the flight crew had evacuated the airplane, ARFF personnel entered the flight deck area through the L1 door. ARFF personnel pulled back the smoke curtain and observed smoke in the main cargo compartment; however, no fire was observed. ARFF personnel opened all of the lower cargo compartments to look for smoke and fire, and no smoke or fire was observed. ARFF personnel also opened the L4 door and then the R4 door, through which they off-loaded some cargo and began water extinguishment operations. The incident commander used a thermal imaging camera to locate hot spots but observed none at this time.

Several attempts were made by ARFF personnel to open the main cargo door by rotating the lockpin handle on the exterior of the door. However, because they could not rotate the handle, they used a Halligan tool[33] to force the handle's movement, which caused the handle to spin freely and rendered it ineffective. Subsequent attempts to open the main cargo door, including efforts to manually operate the door's hydraulic system and to cut through the door's mechanical latches, were also unsuccessful.

About 0040, ARFF personnel opened the right forward overwing hatch using its handle. Flames were observed just aft of the hatch opening, between the tops of the cargo containers and the cabin ceiling. Shortly thereafter, a firefighter began opening the right aft hatch using an axe.[34] ARFF personnel began attacking the fire through the right hatch openings by aiming a water-charged handline over the top of the cargo containers. ARFF personnel subsequently opened the left forward overwing hatch using the handle and the deactivated left aft hatch using an axe. After the left hatches were opened, ARFF personnel began using a water-charged handline from that side.

A thermal imaging camera was again used to locate hot spots to determine where HRET/SPN piercing operations should be concentrated.[35] After locating a hot spot on the crown on the right side of the airplane, forward of the wing, ARFF personnel began piercing attempts at this location. After unsuccessful piercing attempts in which the nozzle tip slipped and moved out of place, the ARFF vehicle was repositioned aft of the right wing, and another attempt was made to pierce the top of the airplane; however, the nozzle tip again slipped and moved out of place.

Piercing operations with the HRET/SPN moved to the left side of the airplane and were successful, and water was applied to the interior of the airplane. The piercing locations began aft of the aft overwing hatch, continued aft toward the tail, and were just above the windows. While piercing operations were conducted on the left side of

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[33] A Halligan tool is a multipurpose tool commonly used in ARFF responses for prying, twisting, punching, or striking. The tool has a fork at one end and a wedge and tapered pick on the other.

[34] At the time of the accident, the Emergency Response diagrams that the ARFF responders had were for the passenger version, not the cargo version, of the DC-8 and did not show which hatches were deactivated. ARFF responders stated that they did not know that some of the hatches were deactivated and their handles inoperable.

[35] According to one of the fire chiefs, burnthrough had not yet occurred at the time that the thermal imaging and piercing operations began.

the airplane, aqueous film-forming foam (AFFF)[36] was also directed through the R4 door opening.

The first fuselage burnthrough occurred about 0200 and was located in the crown of the fuselage aft of the wings. About this time (about 2 hours after landing), ARFF units began discharging AFFF from the HRET/SPN's primary turret through the pierced skin of the airplane and the area of the fuselage that had burned through. All of the fire was located between the overwing hatches and the tail of the airplane. The fire was characterized as being "fully involved" around 0220. ARFF personnel reported that the fire was under control about 0407.

1.15.3 Hazardous Materials Information Retrieval

As noted, during the evacuation, both the captain and the first officer were unsuccessful in their attempts to locate the NOTOC, which they believed should have been behind the captain's seat. The flight engineer stated that the NOTOC fell onto the floor during the flight and that he picked it up and "wedged it in the crash axe sheath on the bulkhead aft of the flight engineer's station."

After a firefighter entered the cockpit and could not locate the NOTOC, the incident commander requested that an airport operations duty officer obtain a flight manifest from UPS so that the hazardous materials could be identified. The duty officer returned to the accident scene with information about the location of the hazardous materials on board the airplane (but not the type of hazardous materials), as provided by a UPS ramp supervisor. The duty officer told ARFF personnel that he could not specifically identify the hazardous materials on the airplane because the UPS ramp supervisor had indicated that such information is only contained in the NOTOC.

The UPS representative then told a firefighter that the NOTOC should be either in the pocket behind the captain's seat or in a pouch on the wall behind the cockpit. Subsequently, a firefighter reentered the cockpit, eventually located the NOTOC, and threw it out of the airplane. The UPS representative stated that he picked up the NOTOC and provided the information to the incident commander. At this point, about 35 minutes had passed since the airplane had landed.

No record was found indicating that any information was exchanged on the day of the accident between UPS personnel at PHL and Flight Control in Louisville, Kentucky, which is responsible for providing information to ARFF personnel regarding the hazardous materials loaded on board an aircraft during in-flight emergencies. The only copy of the NOTOC present at the scene postaccident was the original copy of the documentation recovered from the airplane.

[36] According to an ARFF representative, extinguishing operations initially used water because they were unsure which hazardous materials were on board and because the AFFF was being saved to fight a possible fuel-fed fire.

1.16 Tests and Research

1.16.1 Laboratory Examinations of the Main Cargo Container Contents

About 34 items were removed from the main cargo compartment for further examination at the Safety Board's Materials Laboratory.[37] These items included numerous laptop computers of various makes and models, secondary (lithium-ion) lithium battery packs,[38] several loose secondary lithium battery cells, several unidentified electronic devices without power supplies, and one electronic device with a power supply. The exact location of these items when originally loaded could not be determined because they might have been moved from their original locations during firefighting efforts.

Each item was photographed and examined in detail, and its condition was fully documented. Some items were taken apart to examine the interior components. Most of the laptop computer outer cases were sooted and melted. All of the batteries within the laptop computers were found intact. Almost all of the secondary lithium battery packs were found intact. Several of the laptop batteries exhibited a white substance on their caps, and a few exhibited slight bulging. The loose secondary lithium battery cells were found intact with some extrusion through the caps and slight bulging. All of the unidentified electronic devices were sooted and scorched, and some of the material was consumed by fire. The secondary lithium battery in the powered electronic device was found intact and exhibited a white substance on the cap.

1.16.2 Shipment Identification Effort

Because the fire damage was greatest in cargo containers 12, 13, 14, 16, and 17, efforts were made to identify the items shipped in these containers.[39] A joint group consisting of Safety Board investigators and FAA and UPS representatives attempted to contact each shipper by telephone. Most of the shippers were contacted and were able to provide some information on the contents of the packages. As a result of the calls, about 25 of the items were identified as electronic devices that potentially contained batteries, including laptop computers, two uninterrupted power supplies, a digital video recorder, and several credit card readers and bar code scanners. The remainder of the items were identified as general freight, including clothing, food, machine parts, CDs, digital video discs, medical supplies, documents, and computer parts.

Many of the shippers could not be contacted. Seventy-three of the items, including most of the laptop computers,[40] were identified by claim information provided by UPS,

[37] Investigators eliminated completely intact and identifiable items or damaged items in which the internal power source was intact and undamaged.

[38] There are basically two types of lithium batteries: secondary (rechargeable) and primary (nonrechargeable). For more information about lithium batteries, see section 1.18.6.

[39] All of the cargo in containers 15 and 18 was accounted for during the on-scene examination.

[40] The claim information for the laptop computers did not have the manufacturer information.

and 184 of the items had no claim information and could not be identified. None of the contacted shippers stated that they shipped any items that would be regulated by the Department of Transportation (DOT) as a hazardous material.

1.16.3 Hazardous Materials Identification

Two packages of declared hazardous materials were recovered during the initial phase of the cargo debris examination. According to the material safety data sheets provided by UPS for these items, a class 3 flammable liquid was located in cargo container 3, and a consumer commodity shipment[41] was located in cargo container 14. Both items were found in their original outer packaging: DOT-authorized fiberboard boxes, which were properly labeled. The contents were found completely intact and undamaged. In addition, UPS records indicated that dry ice (class 9 miscellaneous hazardous material) was located in main cargo container 8 and lower cargo compartment 33.

Additional hazardous materials were also found during the examinations of the cargo debris, but the items had not been declared as hazardous materials and, therefore, had not been included in the flight manifest. These undeclared items included an uninterruptible power source (class 8 corrosive material) located in cargo container 11, neoseal gasket cement (class 3 flammable liquid) located in cargo container 13, and a flexible utility lighter with butane refill (division 2.1 flammable gas), nail polish remover (class 3 flammable liquid), and an unidentified polish remover (hazardous class unknown), all located in cargo container 17. All of the items were found completely intact, except for the uninterruptible power source and the various plastic polish remover bottles. The uninterruptible power source was found relatively intact, with its outer casing partially melted. The nail polish remover bottles were found moderately melted, and the unidentified polish remover bottles were found mostly melted.

1.17 Organizational and Management Information

UPS is a global package delivery service operating in more than 200 countries and territories worldwide. The company's corporate office is in Atlanta, Georgia, and the airline is based in Louisville, Kentucky. At the time of the accident, UPS operated a fleet of airplanes consisting of Airbus 300s; Boeing 727s, 747s, 757s, and 767s; DC-8s; and McDonnell Douglas MD-11s.

1.17.1 Operational Guidance

The UPS DC-8 AOM contains emergency and abnormal checklists and procedures. The AOM states, "the first priority is always to fly the airplane and maintain control." The manual also states the following:

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41 Title 49 CFR 171.8 defines a consumer commodity as "any material that is packaged and distributed in a form intended or suitable for sale through retail sales agencies or instrumentalities for consumption by individuals for purposes of personal care or household use."

> the successful handling of emergencies is largely dependent on proper cockpit resource management under the leadership of the captain . . . the pilot flying initially determines the exact nature of the problem and calls for a specific emergency or abnormal checklist. In the event the first officer is PF [pilot flying] when a malfunction occurs, decision[s] regarding which checklist to accomplish . . . are always subject to final determination by the captain.

Further, the AOM states, "it is not possible to develop a procedure for all conceivable situations . . . crews may have to combine elements of more than one procedure or exercise judgment to determine the safest course of action."

The AOM contains four checklists that could have been applied to address the situation on the accident flight: the Pack Smoke checklist, the Fumes Evacuation checklist, the Lower and/or Main Cargo Compartment Smoke or Fire checklist, and the Smoke of Unknown Origin or Suspected Electrical Fire checklist.[42]

1.17.1.1 Pack Smoke Checklist

According to the UPS DC-8 AOM, smoke entering the cockpit through the air conditioning ducts can generally be attributed to one of the engines, one of the air conditioning packs, or the air conditioning ducting. The manual states that the Pack Smoke checklist procedures are geared to identify the air conditioning pack or engine from which the smoke is emanating and then to either turn it off or cut off its bleed air output. The first few steps of the Pack Smoke checklist are as follows:

- don oxygen masks and smoke goggles,
- turn off the recirculation fan,
- close the pneumatic crossfeed valve, and
- turn off each air conditioning pack to try and identify the faulty pack.[43]

The checklist states that, if the smoke dissipates, the flight crew should leave the identified pack off and make specified operational adjustments to cruise altitude and/or operable pack flow as necessary.

1.17.1.2 Fumes Evacuation Checklist

The UPS DC-8 AOM contains a Fumes Evacuation checklist; however, the manual does not provide guidance on when to use the checklist. The Fumes Evacuation checklist includes, in part, the following steps:

- don oxygen masks (set to 100 percent and ON) and goggles,

[42] The Quick Reference Handbook in the cockpit, which is available for rapid recovery and reference by the flight crew, also contained these four emergency checklists.

[43] The manual states that, after turning off an air conditioning pack, it is necessary to wait about 30 to 60 seconds to see if the smoke clears.

- turn air conditioning packs on and set at maximum flow (to provide maximum airflow through the aircraft to reduce the concentration of fumes),
- turn off the recirculation fan (to prevent fumes from being introduced into air distribution ducts and contaminating the flow of fresh pack air),
- close cockpit door and louvers (to create a barrier between the flight station and the cargo compartment; airflow will move toward the tail of the aircraft, reducing fumes in the cockpit),
- fully open all cockpit air outlets (to provide maximum airflow through the cockpit),
- initiate descent to 10,000 feet (to begin to reduce cabin differential pressure),
- maintain cabin altitude (Manually maintaining the cabin altitude at the existing altitude reduces cabin differential pressure. Increasing cabin differential will reduce airflow through the aircraft and may increase fume concentration. A higher cabin altitude could increase evaporation or aggravate leakage of the substance causing fumes.), and
- evacuate aircraft as required.

Further, the Fumes Evacuation checklist in UPS' Quick Reference Handbook (QRH) has an additional step stating that, after maintaining cabin altitude, the flight crew should land the airplane as soon as possible. This step was highlighted by a revision bar in the QRH dated December 1, 2005, which was effective at the time of the accident. UPS indicated that this step was added to the QRH as a result of the September 2, 1998, Swissair Transport Limited accident involving an MD-11.[44]

1.17.1.3 Lower and/or Main Cargo Compartment Smoke or Fire Checklist

According to the Lower and/or Main Cargo Compartment Smoke or Fire checklist contained in the UPS DC-8 AOM, when smoke and/or fire are detected in the aircraft, all flight crewmembers must don their oxygen masks and smoke goggles as soon as possible. The checklist states that, if a warning in the cockpit indicates lower cargo smoke or fire and/or main cargo compartment smoke or fire, the following steps should be taken:

- shut off one air conditioning pack and select minimum flow for the other pack,
- turn off the recirculation fan,
- open the overhead diffuser valves,
- close the main cargo air shutoff valve,
- close the cockpit doors and louvers,
- turn off the radio rack blower switch,

[44] For more information, see Transportation Safety Board of Canada, *In-flight Fire Leading to Collision with Water, Swissair Transport Limited, McDonnell Douglas MD-11, HB-IWF, Peggy's Cove, Nova Scotia, 5 nm SW, 2 September 1998,* Aviation Investigation Report A98H0003 (Quebec, Canada: TSB, 2003).

- manually set and maintain cabin differential pressure at 0.5 pounds per square inch, and
- land as soon as possible.

The checklist contains additional steps to take if an immediate landing is not possible or if the cabin altitude exceeds certain limits.

After the accident, UPS revised its Lower and/or Main Cargo Compartment Smoke or Fire checklist (effective August 1, 2006) by renaming it the "Cargo Smoke or Fire" checklist and changing the second step of the checklist to "land as soon as possible." Further, the revised checklist was expanded to incorporate both the Approach and Landing checklists.

1.17.1.4 Smoke of Unknown Origin or Suspected Electrical Fire Checklist

The UPS DC-8 AOM states that, before starting the checklist, all cockpit indications must be checked to ensure that the fire is electrical in nature (or unknown) and not related to another source, such as cargo fire or air conditioning packs. The manual states that, if the smoke or fire is not electrical in nature, the Cargo Smoke and Lower Cargo Fire lights and the cockpit air conditioning outlets should be checked. The AOM further states that all electrical indications must be thoroughly scanned to note any obvious signs of electrical anomaly. The checklist contains the following steps, in part:

- put on oxygen masks and goggles,
- notify ATC,
- land as soon as possible,
- lock the manual pressure control lever, and
- turn off the recirculation fan.

The procedure continues with additional steps to isolate the electrical source of the smoke or suspected electrical fire.

1.17.2 On-Board Hazardous Materials Procedures

As noted, UPS uses a NOTOC to provide all shipping documentation about the hazardous materials on the airplane to the PIC. The NOTOC consists of customer-prepared shipping papers, which accompany each hazardous materials package and are placed inside individual container pouches. The shipping papers include, in part, a shipping description, package reference and UPS account number, label information, and shipper's certification.

According to the UPS Flight Operations Manual (FOM) in effect at the time of the accident, company acceptance auditors review the shipping papers for accuracy and completeness before hazardous materials shipments are accepted from customers and loaded onto the airplane. The FOM further states that pilots should familiarize themselves with the hazardous materials shipments on board and their container positions. The NOTOC is provided to the captain by the load supervisor before departure. The FOM also states that the NOTOC should be placed in an air DG envelope and that the envelope should be located at some easily accessible location in the cockpit.

The UPS FOM states that, if an emergency is declared and hazardous materials are on board the airplane, ARFF personnel should be informed of the nature and location of the materials, if practicable. The manual also states that the DG envelope should be taken off the airplane by the flight crew during egress and given to ARFF personnel.

The UPS corporate regulated goods manager testified at the Safety Board's public hearing on the UPS accident, which was held in Washington, D.C., on July 12 and 13, 2006, that UPS' Flight Control Group in Louisville, Kentucky, is responsible for providing information to ARFF personnel regarding the hazardous materials loaded on board an aircraft during in-flight emergencies, upon request, and that no specific individual is responsible for contacting Flight Control about an emergency. He indicated that the call could be made by ATC, a flight crewmember, or UPS ground personnel and that, if the airplane landed at an airport other than its destination, ATC or the flight crew would be responsible for contacting Flight Control. He stated that, once a request is received, Flight Control retrieves the information from UPS' Hazardous Materials Information System (HMIS) and proceeds to either e-mail or fax the information to the destination or emergency airport to ensure that the information can be relayed to ARFF responders.

The HMIS was available at PHL when the accident occurred. However, only some UPS personnel were authorized to use it, and they had limited access, which allowed them to view only the number and location of DG shipments on board an aircraft. Further, UPS personnel at PHL were not directed to retrieve the information from the HMIS because all inquiries are supposed to go through Flight Control.

1.17.3 Postaccident Actions

Since the accident, UPS has revised its FOM, Airport Operations Methods Manual (AOMM), and Airline Emergency Response Manual, which guide flight crews, ground personnel at UPS gateways, and Flight Control personnel, respectively.

On April 14, 2006, UPS published Must Read Bulletin 06-11, which informed flight crews of Flight Control's capabilities and clarified Flight Control's accessibility to both UPS and outside parties in emergency situations. The information contained in this bulletin was subsequently incorporated into the company's FOM, effective November 15, 2006. The new paragraph incorporated into the FOM states the following:

> From the duration of block-out to block-in, UPS Flight Control personnel have access to an electronic database regarding the type, quantity and load position of Dangerous Goods aboard each aircraft. If necessary during an in-flight emergency, the Flight Crew can provide the following telephone contact number . . . when addressing outside inquiries from ARFF

> personnel or other persons deemed necessary as to the Dangerous Goods being transported aboard aircraft.

UPS revised its AOMM, effective June 23, 2006, to instruct UPS airport personnel to contact Flight Control for hazardous materials information in the event of an emergency. The revised AOMM included the following language:

> Contact Flight Control for an inventory of any hazardous material transported aboard the aircraft involved in the incident. This information should be made available to airport rescue, firefighting and/or control tower personnel upon request.
>
> > **NOTE:** Flight Control personnel have access to the type, quantity and load position of any hazardous material utilizing the Hazardous Material Information System (HMIS).

UPS revised the emergency response checklist for the Flight Control shift manager, which is found in both the Airport Emergency Response Manual and the Flight Control Department Procedure Manual, effective June 30, 2006, to ensure that hazardous materials information is disseminated to the appropriate parties as quickly as possible. The checklist now requires that the shift manager check HMIS to identify any hazardous materials on board an airplane immediately upon notification of an emergency; communicate to ARFF the results of the search, indicating whether hazardous materials are on board; if unable to contact ARFF, contact the ATCT; and record the name and time of contact.

1.18 Additional Information

1.18.1 Industry Initiatives on Smoke, Fire, and Fumes Checklist Procedures

In late 2004, the Flight Safety Foundation began an international initiative to improve checklist procedures for airline pilots confronting smoke, fire, or fumes when no alerts are annunciated in the cockpit.[45] Manufacturers, airlines, pilots, and government representatives participated in the initiative, which included conference calls, workshops,

[45] The industry initiative was developed partially in response to the 1998 Swissair accident at Peggy's Cove, Nova Scotia, Canada, in which a momentary smoke event evolved, after several minutes, into a sudden and severe in-flight fire. As a result of this accident, the Transportation Safety Board of Canada (TSB) issued Recommendation A00-18 to Transport Canada, the FAA, and the Aircraft Accident Investigation Bureau of Switzerland on December 4, 2000, which asked that "appropriate regulatory authorities take action to ensure that industry standards reflect a philosophy that when odour/smoke from an unknown source appears in an aircraft, the most appropriate course of action is to prepare to land the aircraft expeditiously." Recommendation A00-18 is classified "Fully Satisfactory" as a result of regulatory/industry response. The TSB also issued recommendation A00-19 to Transport Canada, which asked that "appropriate regulatory authorities ensure that emergency checklist procedures for the condition of odour/smoke of unknown origin be designed so as to be completed in a timeframe that will minimize the possibility of an in-flight fire being ignited or sustained." Recommendation A00-19 is classified "Satisfactory In Part" awaiting further action.

and an industry symposium on March 2 and 3, 2005. As a result of the initiative, the Flight Safety Foundation published a report titled, "Flight Crew Procedures Streamlined for Smoke/Fire/Fumes."[46] The report contained a Smoke, Fire, and Fumes checklist template to standardize and optimize flight crew responses to such events.

The proposed industry checklist guidelines remind pilots that a "diversion may be required" if evidence of smoke, fire, or fumes exists and contain steps to eliminate any operational procedures that would delay a diversion. The initial steps of the proposed checklist consist of a series of simple, rapid actions to address the most likely sources of fire. The guidelines state that these actions should require no decision-making by the flight crew, be airplane-specific, and be determined by the manufacturer based on event history for each specific model airplane.

According to the proposed checklist guidelines, unless clear visual evidence exists that all fire hazards are resolved after the initial steps, the flight crew should initiate a diversion, and the crew should not delay landing to continue the checklist for additional source identification and/or source isolation or elimination. The guidelines also recommend the development of an integrated checklist with initial steps that do not require the flight crew to choose among competing checklists, such as Electrical or Air Conditioning based on smoke, fire, or fumes. Specifically, there are instructions that an operator's Smoke or Fumes Evacuation checklist should be performed only after the fire has been extinguished or at such time as smoke or fumes become the greatest threat. The guidelines further state that smoke removal may change the airflow and worsen the situation by fanning or masking an ignition source.

In April 2007, Boeing issued a Flight Operations Technical Bulletin titled, "New Unannunciated Smoke, Fire, and Fumes Non-Normal Checklist," which advised its customers of upcoming new checklist procedures related to unalerted smoke, fire, and fumes events. Boeing indicated that it plans to issue revised flight and operations manuals for each of its most current model airplanes to reflect the smoke, fire, and fumes industry initiative by the end of 2007.[47] Specifically, the new manuals will provide recommended smoke, fire, and fumes checklists and QRH guidance based on the industry-developed template that will include airplane-specific initial actions to be taken by pilots based on Boeing's analysis of the event history for each specific model airplane. Boeing indicated that, for older airplanes like the DC-8,[48] it would not provide updated manuals because many of these airplanes have also undergone extensive changes and modifications by the operators (for which no Boeing records exist). Also, the industry smoke, fire, and fumes philosophy was developed on the basis of new generation aircraft with two-person flight crews. Instead, Boeing indicated that it plans to act as a general resource for customers

[46] Flight Safety Foundation, "Flight Crew Procedures Streamlined for Smoke/Fire/Fumes," *Flight Safety Digest* (Alexandria, Virginia: FSF, 2005), pp. 31-35.

[47] Boeing indicated that it will publish revised manuals by the end of 2007 for Boeing 737 (models 200 through 900), 747 (models 400 and Classic), 757, 767, 777, and Boeing Business Jet airplanes and that it will publish revised manuals in spring 2008 for 717, MD-10, MD-11, and MD-80/90 airplanes.

[48] Boeing indicated that models not currently scheduled to receive revised manuals include Boeing 707, 727, DC-8, DC-9, and DC-10 airplanes.

to upgrade pilot guidelines in accordance with the procedures advocated by the industry initiative.

On January 8, 2004, the FAA issued AC 120-80, "In-Flight Fires,"[49] which provides crewmembers guidance on how to deal with in-flight fires, emphasizing the importance of flight crewmembers taking immediate and aggressive action when signs of an in-flight fire are present. The AC also discusses the importance of recognizing and quickly assessing the conditions that may be associated with hidden fires. The AC does not contain guidance related to specific checklist usage during such situations. Although the FAA was a participant in the industry group's efforts to address nonalerted in-flight smoke, fire, and fumes events, it has not revised existing guidance to reflect the initiative's recommendations.

On January 24, 2007, the FAA held a Cabin Smoke and Fire Workshop, which was prompted by ongoing FAA concerns about in-flight smoke incidents and diversions. The FAA reported at the workshop that about two-thirds of the in-flight cockpit or cabin smoke reports received from 2000 to 2006 involved no smoke or fire and that most of the reports were related to air conditioning and distribution sources or faulty smoke and fire detection systems. The FAA did note that the events were not without risk because they often led to diversions, rushed approaches, overweight landings, and evacuations.

1.18.2 Previously Issued Safety Recommendations Resulting from This Accident

Safety Recommendation A-06-65

As a result of the UPS accident, on September 25, 2006, the Safety Board issued Safety Recommendation A-06-65 to the FAA to address the potential safety consequences if a pilot fails to notice that a runway change has been incorporated in a new landing clearance provided by ATC. Safety Recommendation A-06-65 asked the FAA to do the following:

> Amend FAA Order 7110.65, "Air Traffic Control," to require that, when amending a runway assignment, controllers provide a specific instruction to the pilot advising of the runway change. For example, "UPS 1307, change to runway 25L, cleared to land."

On December 19, 2006, the FAA responded that it was evaluating the potential operational effects of implementing the procedural change recommended by the Safety

[49] AC 120-80 was issued in response to Safety Recommendation A-01-83, which the Safety Board issued on January 4, 2002, as a result of several commercial aviation accidents involving in-flight fires. Safety Recommendation A-01-83 asked the FAA to "issue an AC that describes the need for crewmembers to take immediate and aggressive action in response to signs of an in-flight fire." The recommendation further stated that "the AC should stress that fires often are hidden behind interior panels and therefore may require a crewmember to remove or otherwise gain access to the area behind interior panels in order to effectively apply extinguishing agents to the source of the fire." The Board classified Safety Recommendation A-01-83 "Closed—Acceptable Action" on April 15, 2004.

Board and its associated revision to FAA Order 7110.65. The FAA stated that it should have the evaluation completed and further response provided to the Board in 120 days. Pending the results of the FAA's evaluation and appropriate changes to FAA Order 7110.65, the Board classified Safety Recommendation A-06-65 "Open—Acceptable Response" on May 2, 2007. In correspondence dated November 27, 2007, the FAA stated that it would be issuing a notice implementing the change to add the phraseology "runway change" to FAA Order 7110.65, "Air Traffic Control," by the end of 2007.

1.18.3 Previous Related Safety Recommendations

1.18.3.1 Smoke and Fire Detection, Suppression, and Extinguishment

The Safety Board has had longstanding concerns about smoke and fire detection, suppression, and extinguishment on cargo airplanes and has issued several safety recommendations as a result of its investigations of accidents related to these issues.

Safety Recommendations A-88-122 and -123

On February 3, 1988, an in-flight fire occurred on American Airlines flight 132 while it was en route to Nashville, Tennessee. The Safety Board determined that undeclared and improperly packaged hazardous materials had been loaded in the midcargo compartment with the passenger luggage and had caused the fire.[50] On October 24, 1988, the Board issued Safety Recommendations A-88-122 and -123, which asked the FAA to require fire and smoke detection systems and fire extinguishment systems, respectively, in all class D cargo compartments.

In a January 5, 1989, letter, the FAA stated that it was considering a notice of proposed rulemaking (NPRM) to "amend 14 CFR Parts 25, 121, and 135 to require fire and smoke detection and fire extinguishing systems for all class D cargo compartments that are more than 200 cubic feet in volume." However, in an August 10, 1993, letter, the FAA stated that it had conducted economic and cost-benefit analyses, which found that "the proposed rule would not have provided a significant degree of protection to the occupants from the extremely severe fire." As a result, the FAA terminated the rulemaking action, and, on October 14, 1993, the Safety Board classified Safety Recommendations A-88-122 and -123 "Closed—Unacceptable Action."

Safety Recommendation A-97-56

On May 11, 1996, ValuJet Airlines, Inc., flight 592, crashed into the Everglades about 10 minutes after takeoff from Miami International Airport, Miami, Florida. The Safety Board determined that one of the probable causes of the accident was the FAA's failure to

[50] National Transportation Safety Board, *In-Flight Fire, McDonnell Douglas DC-9-83, N569AA, Nashville, Tennessee, February 3, 1988*, Hazardous Materials Report NTSB/HZM-88/02 (Washington, DC: NTSB, 1997).

require smoke detection and fire suppression systems in class D cargo compartments.[51] As a result, on September 9, 1997, the Safety Board issued Safety Recommendation A-97-56, which asked the FAA to "expedite final rulemaking to require smoke detection and fire suppression systems for all class D cargo compartments."

On June 13, 1997, the FAA issued an NPRM, which proposed to require the installation of smoke detection and fire suppression systems in class D cargo compartments. According to the NPRM, the airline industry would have 3 years from the effective date of the final rule to meet the new standards. The FAA indicated that it anticipated issuing a final rule by the end of 1997.

On February 12, 1998, the FAA issued a final rule, 14 CFR 121.314, which eliminated class D compartments as an option for future type certification and required that compartments that could no longer be classified as "class D" compartments be classified as "class C" or "class E" compartments, as applicable. Further, the class D compartments in certain transport-category airplanes manufactured under existing type certificates and used in passenger service were required to meet the smoke detection and fire suppression standards for class C compartments by March 2001 for air carrier or most other commercial services. Cargo-only operations were allowed to reclassify "class D" compartments as "class E"[52] compartments. On the basis of the FAA's actions, the Board classified Safety Recommendation A-97-56 "Closed—Acceptable Action" on August 13, 1998.

Safety Recommendations A-98-78 and -79

On September 5, 1996, FedEx flight 1406 made an emergency landing at Stewart International Airport, Newburgh, New York, after the flight crew determined that there was smoke in the cabin cargo compartment. The Safety Board determined that the probable cause of this accident was an in-fight cargo fire of undetermined origin.[53] In its final report on the accident, the Board concluded that, at that time, "inadequate means exist[ed] for extinguishing on-board aircraft fire." As a result, the Board issued Safety Recommendation A-98-78, which asked the FAA to "reexamine the feasibility of on-board airplane cabin interior fire extinguishing systems for airplanes operating under 14 CFR Part 121 and, if found feasible, require the use of such systems."

On October 27, 1998, the FAA responded that cargo operations differ from passenger operations and that ventilation shutoff and depressurization were sufficient means to control a fire in a class E compartment until the flight crew could land. The FAA stated that, although it had a test program in progress to evaluate the feasibility of built-in systems for use in the cabins of very large, high-capacity passenger airplanes, it

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[51] National Transportation Safety Board, *In-Flight Fire and Impact with Terrain, ValuJet Airlines, Inc., Flight 592, DC9-32, N904VJ, Everglades Near Miami, Florida, May 11, 1996*, Aircraft Accident Report NTSB/AAR-97/06 (Washington, DC: NTSB, 1997).

[52] Class E compartments are required to have fire and smoke detection systems but are not required to have fire suppression systems.

[53] National Transportation Safety Board, *In-Flight Fire/Emergency Landing, Newburgh, New York, Federal Express Flight 1406, Douglas DC-10-10, N68055, September 5, 1996,* Aircraft Accident Report NTSB/AAR-98/03 (Washington, DC: NTSB, 1998).

had no plans to initiate rulemaking for such systems. In addition, the FAA stated that the requirement of a fire suppression system would add "considerable weight" to the aircraft and reduce the amount of cargo that could be carried. The Safety Board found the FAA's actions to be consistent with Safety Recommendation A-98-78 and, on April 22, 1999, classified the recommendation "Closed—Acceptable Action," and the Board encouraged the FAA to continue evaluating fire suppression systems for use in the cabin areas of cargo operations.

The Safety Board also issued Safety Recommendation A-98-79, which asked the FAA to do the following:

> Review the aircraft cabin interior firefighting policies, tactics, and procedures currently in use, and take action to develop and implement improvements in firefighter training and equipment to enable firefighters to extinguish aircraft interior fires more rapidly.

In its October 27, 1998, response letter, the FAA stated that, as a result of its research and development, an HRET/SPN had been developed. In 1999, the Safety Board responded that it appreciated the FAA's actions and encouraged it to continue its efforts to improve fighting interior cabin fires. On the basis of the FAA's actions and its continued support of firefighting programs nationwide, the Safety Board classified Safety Recommendation A-98-79 "Closed—Acceptable Action" on April 22, 1999.

1.18.3.2 Retrieval and Availability of Hazardous Materials Information

Safety Recommendation A-98-80

In its final report on the investigation of the in-flight fire and emergency landing involving FedEx flight 1406 in Newburgh, the Safety Board addressed the importance of quickly providing hazardous materials information to emergency responders. The investigation revealed that emergency responders did not receive specific information concerning the identity of hazardous materials, their quantities, or the number of packages on the aircraft during the firefighting phase of the emergency response. Although the unavailability of such information did not affect the firefighting efforts, the overall importance of the timeliness in which emergency responders receive specific information about hazardous materials and the potential implications of unawareness were emphasized in the Board's report.

In the Newburgh report, the Safety Board also noted that the survivability of shipping documents on board aircraft is much less likely than that for surface modes of transportation because of the inherent risk of fire or total destruction associated with aviation accidents. The Board also noted that it would be very unlikely that flight crewmembers would be able to retrieve shipping papers before evacuating an airplane because of the dangers of on-board fires. As a result, operators needed to provide the information contained in these documents to emergency responders. During its investigation, the Board determined that Federal regulations did not adequately address the need for hazardous materials information on file at a carrier to be quickly retrievable in a format useful to emergency responders. As a result, the Board issued Safety Recommendation A-98-80 to the Research and Special Programs Administration (RSPA), which stated the following:[54]

> Require, within 2 years, that air carriers transporting hazardous materials have the means, 24 hours per day, to quickly retrieve and provide consolidated, specific information about the identity (including proper shipping name), hazard class, quantity, number of packages, and location of all hazardous materials on an airplane in a timely manner to emergency responders.

On March 25, 2003, RSPA published a final rule, which revised 49 CFR 175.33 to mandate that air carriers have hazardous materials information immediately available for emergency responders. Specifically, 49 CFR 175.33(d), as revised, stated the following:

> The aircraft operator must have . . . a copy of the [NOTOC], an electronic image thereof, or the information contained therein readily accessible at the airport of departure and the intended airport of arrival for the duration of the flight leg and, upon request, must make the information immediately available, in an accurate and legible format, to any representative of a Federal, State, or local government agency (including an emergency responder) who is responding to an incident involving the flight. (emphasis in original)

The Safety Board stated that it appreciated RSPA's action to require air carriers to be able to immediately provide hazardous materials information upon request. However, because the revision did not address the need for providing such information in the form of a consolidated list that would be more easily read and understandable, the Board classified Safety Recommendation A-98-80 "Closed—Unacceptable Action" on August 18, 2003.

1.18.3.3 Air Transport of Lithium Batteries

Safety Recommendations A-99-80 and -82

On April 28, 1999, a fire destroyed freight, including lithium batteries, on two aircraft cargo pallets at the Northwest Airlines cargo facility at Los Angeles International Airport, Los Angeles, California. The cargo pallets had been taken off an inbound passenger-carrying flight from Osaka, Japan. The Safety Board's investigation of this incident revealed that lithium batteries likely presented an unacceptable risk to aircraft and passengers that required immediate attention. As a result, on November 16, 1999, the

[54] The Safety Board concurrently issued Safety Recommendation A-98-75, which contained the same text, to the FAA. On April 22, 1999, the FAA responded that RSPA would act as the lead agency on this issue and would keep the Board informed on the progress. RSPA responded that it was working jointly with the FAA to address Safety Recommendation A-98-75. Therefore, on April 22, 1999, the Board classified Safety Recommendation A-98-75 "Closed—No Longer Applicable."

Safety Board issued Safety Recommendations A-99-80 and -82,[55] which asked RSPA to do the following:

> With the FAA, evaluate the fire hazards posed by lithium batteries in [an] air transportation environment and require that appropriate safety measures be taken to protect aircraft and occupants. The evaluation should consider the testing requirements for lithium batteries in the United Nations' [UN] *Transport of Dangerous Goods Manual of Tests and Criteria*, the involvement of packages containing large quantities of tightly packed batteries in a cargo compartment fire, and the possible exposure of batteries to rough handling in an air transportation environment, including being crushed or abraded open. (A-99-80) [56]
>
> Require that packages containing lithium batteries be identified as hazardous materials, including appropriate marking and labeling of the packages and proper identification in shipping documents, when transported on aircraft. (A-99-82)

In a September 26, 2002, letter regarding these recommendations, the Safety Board stated that, although PHMSA and the FAA had fully responded to Safety Recommendation A-99-80 with respect to primary lithium batteries, the actions did not address the risks posed by the shipment of secondary lithium batteries. The Board classified Safety Recommendation A-99-80 "Open—Acceptable Response," pending investigation of the fire risks posed by the shipment of secondary lithium batteries and appropriate rulemaking. Further, the Board stated that the proposed requirements did not fully address the Board's concerns regarding the need for cargo handlers to be properly alerted to the dangers posed by lithium batteries. The Board added that, if cargo handlers can determine from shipping documents and the marking and labeling on packages of lithium batteries that the contents contain a hazardous material, they would be more likely to handle the package carefully. The Board urged PHMSA to consider the need to classify packages containing more than 12 small lithium batteries or 24 lithium cells as a class 9 miscellaneous hazardous material, subject to the requirements in the hazardous materials regulations for labeling of the package and shipping papers. The Board classified Safety Recommendation A-99-82 "Open—Acceptable Response," pending issuance of such a requirement.

On December 15, 2004, in response to these safety recommendations and as a result of previous primary (metallic lithium) lithium battery fires in air transportation and FAA primary lithium battery flammability tests conducted in 2004,[57] the Pipeline

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[55] For more information about these safety recommendations, see the Safety Board's Web site at <http://www.ntsb.gov.>

[56] The Safety Board concurrently issued companion Safety Recommendation A-99-85, which is classified "Open—Acceptable Response," to the FAA.

[57] Department of Transportation, *Flammability Assessment of Bulk-Packed, Nonrechargeable Lithium Primary Batteries in Transport Category Aircraft*, DOT/FAA-AR-04/26 (Washington DC: DOT, 2004).

and Hazardous Materials Safety Administration (PHMSA)[58] published an interim final rule. The rule prohibited the transportation of cargo shipments of all individual primary lithium batteries and cells, as well as equipment containing or packed with large lithium batteries (containing more than 25 grams [g] lithium), on board passenger-carrying aircraft. However, the transportation of small (containing no more than 2 g lithium) and medium (containing from 2 to 25 g lithium) primary lithium batteries contained in or packed with equipment was still permitted on board passenger-carrying aircraft.

Shipment of equipment with small and medium primary batteries remained exempted from most requirements for class 9 hazardous materials provided that the batteries and cells complied with 49 CFR 173.185, were packed in strong packaging, and did not exceed a net weight of 5 kilograms (kg) and that the packages contained only the number of batteries needed to power the equipment. Title 49 CFR 173.185 specifies that all shipments of primary lithium batteries, including those contained in or packed with equipment, weighing 35 kg or less may be transported on board cargo-only aircraft; each cell must contain less than 5 g lithium content; each battery must contain less than 25 g lithium content; and the outside of the package must be marked, "PRIMARY LITHIUM BATTERIES – FORBIDDEN FOR TRANSPORT ABOARD PASSENGER AIRCRAFT."

Cargo shipments of secondary lithium batteries and cells, including those contained in or packed with equipment, were still permitted on board passenger-carrying aircraft when the package's gross weight was no more than 5 kg and on board cargo-only aircraft when the gross weight was 35 kg or less. Further, shipments of secondary lithium batteries continued to be exempted from the requirements for class 9 hazardous materials packaging, labeling, marking, and reporting provided that each secondary lithium cell contained no more than 1.5 g of equivalent lithium content and that the secondary lithium battery contained no more that 8 g of equivalent lithium content. The interim final rule was in effect at the time of the UPS flight 1307 accident, and all of the secondary lithium batteries found in the accident debris would have been subject to these exemptions.

On August 9, 2007, PHMSA issued final rule, "Hazardous Materials: Transportation of Lithium Batteries," effective date January 1, 2008, which tightened the regulations contained in 49 CFR Parts 171 to 174 regarding the safe transportation of both primary and secondary lithium batteries. As a result of this final rule, the changes contained in the December 2004 interim final rule were adopted with minor changes. In addition, the following changes were made:

- packaging for small lithium batteries were required to be tested in accordance with the UN Manual of Tests and Criteria;[59]
- communications and packaging requirements for small batteries, applicable to single packages containing more that 24 cells or 12 batteries, were established;

[58] RSPA no longer exists, and PHMSA has assumed its responsibilities, which are discussed in section 1.18.6.

[59] The UN test manual describes the types of tests, including drop, vibration, and crushing tests.

- the exemption for medium lithium cells and batteries, including those packed with or contained in equipment, was eliminated, and these cells and batteries were required to be transported and identified as class 9 hazardous materials and to meet associated hazard communication and packaging requirements when transported by aircraft or vessel; and
- airline passengers and flight and cabin crew are allowed to carry spare lithium batteries on board as carry-on items only.[60]

In the preamble for this rulemaking, PHMSA noted that the Air Line Pilots Association (ALPA) and the International Brotherhood of the Teamsters had expressed concern that primary lithium batteries may still be shipped as cargo on cargo-only aircraft. ALPA suggested that bulk shipments of primary lithium batteries and cells should only be transported on board cargo aircraft if they are subject to all of the applicable packaging, labeling, and marking requirements. The Teamsters suggested that primary lithium batteries should not be transported on board either passenger or cargo aircraft until the risks from these batteries could be mitigated by improved packaging standards, specific labeling and marking requirements, strict quantity limitations, and appropriate hazard communications standards (including pilot notification). In addressing these comments, PHMSA noted that the FAA agreed with its assessment that the greatest risk to public safety is in passenger-carrying operations and that extending the prohibition of transporting primary lithium batteries to cargo operations was beyond the scope of the August 2007 rulemaking. PHMSA noted that it would, therefore, not extend the prohibition of transporting primary lithium batteries to cargo-only aircraft.

In a July 31, 2007, response letter, PHMSA stated that, in addition to issuing the final rule, it was continuing to evaluate the fire hazards posed by the transportation of secondary lithium batteries with the FAA and was currently evaluating a report on this issue prepared by the FAA's Technical Center. PHMSA also stated that it was working with the UN Subcommittee of Experts on the Transport of Dangerous Goods and the International Civil Aviation Organization (ICAO) to develop additional enhanced safety measures for the transportation of lithium batteries and that it had initiated a comprehensive strategy, bringing together public and private-sector stakeholders, aimed at reducing the transportation risks posed by batteries of all types.

1.18.4 Related Federal Aviation Administration Guidance

AC 25-9A, "Smoke Detection, Penetration, and Evacuation Tests and Related Flight Manual Emergency Procedures," revised January 6, 1994,[61] contains guidelines on how to conduct certification tests in compliance with 14 CFR 25.858. The AC states that the objective of the smoke detection test is to "demonstrate that the smoke detection system installation will detect a smoldering fire producing a small amount of smoke." The AC further states the following:

[60] The final rule also describes how to protect the spare batteries to prevent short-circuiting.

[61] AC 25-9, which was issued in 1986, provided guidance to manufacturers on how to conduct certification tests in compliance with 14 CFR 25.858 (see section 1.6.2.3). Before 1986, no such guidance existed.

> A smoldering fire producing a small amount of smoke in conjunction with the applicable detection time has been selected as a fire or failure condition that could be detected early enough to ensure that the fire or smoke procedures would be effective. Subjective judgment, considering the failure, size of compartment, materials contained in the compartment, and the containment methods and procedures, is needed to assess the significance of a small amount of smoke.

AC 25-9A proposes various acceptable smoke generators and materials to be used in the tests, but it does not indicate the exact amount of smoke that needs to be produced for various size cargo compartments. The guidelines suggest that the smoke should be generated at a location that would be considered "critical with respect to the detector's area of coverage" and "in areas where cargo can be loaded and secured by the airplane's onboard loading and restraint system," which would be determined by the aircraft certifying official.

Regarding test conditions, AC 25-9A states the following:

> Flight tests are required to demonstrate compartment accessibility, and exclusion of hazardous quantities of smoke or extinguishing agent from entering into compartments occupied by the crew or passengers. Because detector sensitivity and in-flight compartment airflows differ from those found in ground tests, smoke detection tests should also be conducted in flight . . . The smoke detection system effectiveness test should be conducted during cruise at normal cabin-to-ambient pressure differential with maximum normal ventilation flow rate. The airplane should be operated in the various dispatchable ventilation and pressurization configurations (one air conditioning pack, two air conditioning packs, unpressurized, etc.) for the cruise condition.

AC 25-9A also states, "the results of these tests are valid only if the airplane is maintained in the condition and configuration that was tested." However, the AC does not indicate whether the tests should be conducted with cargo loaded in the cargo compartment, whether cargo containers should be used, or where the detectors should be placed during the tests.

1.18.5 Recent Developments in Fire Detection and Suppression Systems

1.18.5.1 Federal Aviation Administration Rulemaking Initiatives

At the Safety Board's public hearing on the UPS accident, the FAA's branch manager of propulsion and mechanical systems recognized that recent new technologies, including lighter fire suppression materials, have made fire detection and suppression systems for main cargo compartments more feasible to operators. He encouraged the industry to submit new ideas and technologies in fire suppression on board aircraft through rulemaking changes. Further, according to the manager, the FAA is currently reviewing a draft NPRM, which proposes the development of a new compartment classification, class F, to be added to 14 CFR Part 25. The manager stated that the new classification would allow fire detection and suppression systems to use any means of chemical suppression agent and access and could be used on passenger and cargo aircraft.[62] He also stated that all-cargo operations would continue to have class E compartments.

1.18.5.2 Federal Express System Developments

According to testimony from FedEx's vice president of strategic projects, after the fire-related accidents in Newburgh and Uruguay,[63] the company began developing a main cargo compartment fire extinguishing system that would meet the requirements for the proposed class F compartments.[64] FedEx stated that, once the system is developed and approved, it would initially be used on all FedEx airplanes that fly internationally and that, eventually, the system would be installed on all FedEx aircraft. In addition, FedEx has redesigned its standard cargo containers to include all-aluminum construction and improved the cargo door design to better contain fire within an individual container. Each container is monitored with infrared sensors to measure the rate of temperature change in the container. On the main compartment, the system has individual piercing nozzles for each container that are actuated when a set rate of temperature increase occurs in the container. The nozzle pierces the top of the container and injects nitrogen-expanded AFFF into the container. In tests conducted by FedEx, the system activated within 11 minutes of ignition and completely extinguished the fire before it breached the container.

FedEx has also developed a fire-resistant cover called the "Peltz bag," which encases shipments in pallets. Infrared sensors also monitor the rate of temperature change in the pallets. In testing conducted by FedEx, the Peltz bag contained a fire within a pallet for up to 4 hours.

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[62] Currently, class C compartments must have fire suppression systems that have been approved by the FAA, and only Halon suppression systems have been approved by the FAA at this time. Class F systems would allow for the development of new fire containment systems, including fire suppression through agent application.

[63] The Safety Board assisted in the investigation of the April 27, 2004, in-flight fire on board FedEx flight 7145 in Uruguay. About 45 minutes into the flight, the flight crew was alerted about a fire toward the rear of the cargo compartment. Examinations revealed that the debris contained residue of a flammable liquid; however, the source of the residue was not determined.

[64] Other developments in fire detection and suppression systems have been made. For example, as a result of the 1998 accident involving a Swissair MD-11, Swissair and Boeing developed an improved fire detection and suppression system for its MD-11s. The system has dual-channel smoke detectors and infrared detectors mounted in the avionics compartment and in the overhead areas of the forward galley and cockpit. The cockpit was modified to incorporate additional aural and visual warnings, as well as a video display unit for viewing the camera areas. A Halon suppression system was installed to enable suppressant in the cockpit and galley overhead areas. The FAA was involved in reviewing and approving the system through the approval of the certification plans, the flight test plans, and the final Halon suppression capability analysis.

1.18.6 Lithium Batteries

A number of secondary lithium batteries, which are described in more detail below, were found loose and in laptop computers and cell phones in the accident debris. No primary batteries were found in the accident debris.

There are basically two types of lithium batteries: secondary (rechargeable) and primary (nonrechargeable). Secondary lithium batteries, which are commonly used in items such as cameras, cell phones, and laptop computers, contain lithium ions (charged molecules) in a flammable liquid electrolyte. Halon suppression systems (the only fire suppression systems certified for aviation) are effective in extinguishing fires involving secondary lithium batteries.

Primary batteries, which are commonly used in items such as watches and pocket calculators, contain metallic lithium that is sealed in a metal casing. The metallic lithium will burn when exposed to air if the metal casing is damaged, compromised, or exposed to sustained heating. Halon suppression systems are not effective in extinguishing fires involving primary lithium batteries. Both primary and secondary lithium batteries are regulated as hazardous materials for the purposes of transportation.

PHMSA is the designated agency within the DOT charged with the safe and secure transport of hazardous materials by all modes of transportation. PHMSA is responsible for the creation and promulgation of the *Hazardous Materials Regulations* (HMR). Other modal administrations within the DOT, such as the FAA, are responsible for enforcing the HMR for their respective modes. For example, the FAA ensures that air carriers transporting hazardous materials do so in compliance with HMR requirements.

1.18.6.1 Incidents Involving Lithium Batteries

According to an FAA document (titled, “Batteries & Battery-Powered Devices: Aviation Incidents Involving Smoke, Fire, Extreme Heat or Explosion,” revised July 25, 2007) compiling known battery incident data, since February 1996, 82 incidents directly related to all types of batteries were reported to have occurred in the aviation industry. The data showed that 14 of these incidents involved secondary lithium batteries and that 13 of these incidents involved primary lithium batteries.[65]

Of the 14 secondary battery-related incidents, 7 involved items shipped on cargo-only aircraft, 6 involved checked baggage and carry-on items intended for passenger flights, and 1 involved a package shipped as cargo on board a passenger aircraft. Of the seven incidents involving cargo-only aircraft, four occurred post flight, either during unloading or sorting operations or customs inspections; two occurred or were detected before the items were loaded onto the aircraft; and one occurred in flight. Of the seven incidents involving passenger aircraft, two occurred in flight, one causing the flight crew to divert; three occurred on board before takeoff; and two occurred in the airports before boarding the aircraft.

[65] None of these incidents were required to be reported to the FAA because they were exempt from the class 9 hazardous materials reporting requirements.

Of the 13 primary battery-related incidents, 5 involved items shipped or carried by crew on cargo-only aircraft, 6 involved carry-on items intended for passenger flights, and 2 involved packages shipped as cargo on passenger flights. Of the five incidents involving cargo-only aircraft, three occurred post flight, either during unloading or sorting operations; one occurred while en route to a cargo center; and one occurred in flight. Of the eight incidents involving passenger flights, four occurred in flight, two causing the flight crew to divert or land; two occurred or were detected post flight, either during unloading or sorting operations; and two occurred before boarding the aircraft. Although the causes of these lithium battery incidents were not all determined, some of the modes of failure identified in the FAA document included short-circuiting, dropping or mishandling of items, loose batteries packed in bags, and charging of the batteries. However, during the Safety Board's public hearing, representatives of the FAA, PHMSA, Consumer Product Safety Commission (CSPC), and the battery industry noted that the causes of overheating of secondary lithium batteries were not completely understandable or clearly identifiable. Testing and quality control concerns, state of charge, and other damage were discussed as factors or causes of the incidents involving secondary lithium batteries.

A 2006 Safety Board review of the reported battery incident data for the previous 10 years showed an increase in aviation incidents involving both secondary and primary lithium batteries. Specifically, from February 2001 to February 2006, secondary lithium batteries were involved in four aviation incidents compared to the one incident involving secondary lithium batteries in the previous 5-year period. Data from February 2006 to July 2007 showed that the number of incidents (nine) involving secondary lithium batteries was nearly double that of the previous 10 years. Similarly, primary lithium batteries were involved in three incidents from February 1996 to 2001, four in the following 5-year period, and six from February 2006 to July 2007. A review of FAA records confirmed these statistics.

Since August 2006, the CPSC, in cooperation with Dell, Apple, Lenovo, and IBM, has recalled more than 9 million laptops containing secondary lithium batteries, which were prompted by reports of batteries overheating, resulting in two minor injuries and several cases of property damage. The recall warned consumers of the potential for the batteries to overheat in laptop computers and the possible fire hazard to their users. Further, the CSPC has issued five additional recalls for other products containing secondary lithium batteries. During the Safety Board's public hearing, the CPSC predicted that more incidents and recalls would occur if the deficiencies with the secondary lithium batteries were not addressed.

1.18.6.2 Recent Lithium Battery-Related Safety Alerts

On March 22, 2007, PHMSA issued Safety Advisory 07-02, "Transportation of Batteries and Battery-Powered Devices by Airline Passengers and Crew Members," to "inform the traveling public and airline employees about the importance of properly packing and handling batteries and battery-powered devices when they are carried aboard aircraft." The advisory suggested measures for complying with regulations and minimizing transportation risks associated with batteries and battery-powered devices. Concurrently, ALPA issued Safety Alert 2007-03, "Responding to In Flight Passenger

Electronic Equipment Fires," to "educate its members as to the characteristics of a fire involving a portable electronic device."

On August 3, 2007, the FAA issued Information for Operators (InFO) 07016, "PHMSA Guidance on the Carriage of Batteries and Battery-Powered Devices," because it continued to receive reports of cabin smoke or fire suspected to have originated from batteries or battery-powered devices carried in the cabin.[66] The InFO provided the guidance contained in PHMSA Safety Advisory 07-02. The InFO reminded operators to be aware of the risks associated with using primary and secondary batteries and battery-powered devices in the passenger cabin and readdressed the availability of guidance for the safe transport of batteries and battery-powered devices on board aircraft.

[66] InFO 07016 superseded Safety Alert for Operators (SAFO) 07002, which the FAA issued on January 5, 2007, and noted that, since December 2005, "there have been several occurrences of smoke and fires erupting from failures of lithium-ion batteries such as those used within laptop computers." The SAFO alerted crewmembers about the smoke and fire hazards associated with high-energy batteries and reemphasized AC 120-80 and its guidance on how to handle hidden fires.

2. Analysis

2.1 General

The flight crewmembers were properly certificated and qualified under Federal regulations. No evidence indicated any preexisting medical or physical condition that might have adversely affected the flight crew's performance during the accident flight.

Although overnight flight schedules can be tiring and produce cumulative fatigue over successive nights,[67] the accident occurred on only the second night of the trip sequence, and all of the flight crewmembers had made use of sleep opportunities during the day before the flight. Further, the accident occurred less than 2 hours into the trip, about 0000, a time at which neither pilot typically slept.[68] Finally, there was no evidence of performance deficiencies that were clearly discernible and consistent with the known effects of fatigue. Therefore, the Safety Board concludes that no evidence was found indicating that fatigue degraded the performance of any of the flight crewmembers on the day of the accident.

Examinations of the recovered components revealed no evidence of any preexisting powerplant, structural, or system failures.

This analysis discusses the accident sequence, including the flight crew's performance; the quality of fire and smoke emergency checklists; smoke and fire detection and suppression systems on cargo aircraft; cargo aircraft smoke and fire detection systems test certification requirements; ARFF training inadequacies; cargo airplane emergency exit requirements; hazardous materials information dissemination procedures; and issues related to the transport of lithium batteries on cargo airplanes.

2.2 Flight Crew Performance

2.2.1 Actions During Descent and Landing Sequence

The accident flight was uneventful until just after the descent to PHL began, about 2335, at which time, the first officer detected an odor and asked the captain and flight engineer if they smelled anything. The captain stated during postaccident interviews that

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[67] P.H. Grander, K.B. Gregory, L.J. Connell, R.C. Graeber, D.L. Miller, and M.R. Rosekind, "Flight Crew Fatigue IV: Overnight Cargo Operations," *Aviation, Space, and Environmental Medicine*, Vol. 69 (1998), pp. B26-B36.

[68] When off duty, the captain typically went to bed between 0100 and 0200 and the first officer between 0000 and 0100.

he evaluated diversion alternatives at this time but decided to continue to PHL. The flight crew's decision to continue to PHL is discussed further in section 2.2.2.

After the first officer's query, the flight crew began to actively analyze the situation and take action, including looking for visible evidence of smoke or fire in the area behind the cockpit. The flight crew also proactively began troubleshooting to determine the source of the odor. Neither the UPS DC-8 AOM nor the DC-8 Airplane Flight Manual states what procedures should be accomplished in the event that only fumes are present. The flight crew's use of UPS fire and smoke-related checklists and industry efforts to upgrade such checklists are discussed in detail in section 2.2.3.

The Cargo Smoke warning light in the main cargo compartment illuminated about 20 minutes after the first officer first mentioned the presence of an odor. One minute 15 seconds later, the Lower Cargo Fire warning light illuminated and indicated that smoke was in the lower aft middle cargo compartment. After the first warning light illuminated, the flight crew began to execute the Lower and/or Main Cargo Compartment Smoke or Fire checklist, and the first officer turned the airplane toward the airport. CVR evidence indicates that, during this portion of the flight, the first officer maintained control of the airplane and the captain oversaw the crew actions and worked with the flight engineer to handle troubleshooting, communication, and emergency efforts.

2.2.2 Decision to Continue to Philadelphia International Airport

Investigators considered whether the flight crew should have executed a diversion to another airport when the odor was first detected. The flight crewmembers stated during postaccident interviews that they decided to continue to PHL because no smoke detector warning lights illuminated in the cockpit and no smoke was visually evident, which minimized their belief that an actual hazard existed. Further, the crewmembers also noted that unusual odors could be common from nonthreatening factors, such as flying over forest fires or from unusual cargo. Without supporting evidence, such as visible smoke and aural alerts, odor is an elusive and highly subjective factor for determining the presence of a hazard.

Safety Board calculations indicated that, if the flight crew had begun a diversion at the first indication of an odor and performed a standard or emergency descent into Washington Dulles International Airport, Andrews Air Force Base, or Baltimore Washington International Airport, it would have taken about 17 to 18 minutes[69] to land, compared to the 24 minutes it took to land at PHL. Because the flight was already established on the descent to PHL, a diversion would have added cockpit workload that might have affected the crew's ability to focus its attention on the potential smoke or fire hazard. The Safety Board concludes that the flight crew's continued descent to PHL was not inappropriate given that there was no evidence of abnormalities other than the odor and that no cockpit alerts had activated.

[69] This time was based on the 12.5 minutes that calculations showed would have been required for the airplane to descend and reach any of the alternate airports and about 5 minutes for the flight crew to discuss and execute a diversion and to prepare and coordinate the approach with ATC.

2.2.3 Use and Adequacy of Smoke, Fire, or Fumes Checklists

During the review of the flight crew's actions and decision-making, investigators found that company guidance and checklists regarding smoke, fire, or fumes in the absence of a cockpit warning were not adequate because neither UPS nor Boeing provided specific flight crew procedures for responding to such a situation. Instead, the UPS DC-8 AOM provided four checklists that could have been applied to such a situation, three of which were predicated on visible evidence of smoke or fire or an alert activation in the cockpit. As noted, during this period, no smoke or fire warning lights illuminated in the cockpit, no visible evidence of smoke or fire existed, the CVR recorded no comments by the flight crew about burning eyes or headaches, and no evidence of abnormalities other than odor existed. Although one of the checklists, the Fumes Evacuation checklist, did apply specifically to fumes, the AOM did not provide guidance on when to use the checklist.

Increasing both air conditioning packs to maximum flow (as part of the Fumes Evacuation checklist) would have increased the airflow through the cabin. This would have evacuated the smoke more quickly, diluting the air and inhibiting the flight crew's ability to identify the source of the odor and the smoke detectors' ability to detect the smoke. Further, additional oxygen would have been provided to the smoldering fire. Although these would be appropriate steps to take in a situation involving fumes that might, for example, cause irritation or otherwise prevent the flight crew's ability to operate the airplane, they are not appropriate in a situation in which a fire is suspected. Therefore, the Safety Board concludes that the increased airflow that resulted from the Fumes Evacuation checklist actions diluted the smoke and inhibited its detection by either the smoke detection system or flight crewmembers and provided the fire with additional oxygen.

Although the FAA provides guidance to crewmembers on issues related to in-flight fires in AC 120-80, the AC does not provide guidance to flight crews on how to respond to evidence of smoke, fire, and fumes in the absence of a cockpit alert. In 2004, an international initiative was undertaken to improve guidance and checklist procedures in this area. The initiative developed a smoke, fire, and fumes checklist template to standardize and optimize responses to such events. Recognizing that time is critical in responding to any event, the proposed smoke, fire, and fumes checklist guidelines emphasize that flight crews should balance efforts to diagnose and resolve any fire hazard with efforts to evaluate the possibility of diverting; that a crew should have a simple, rapid, integrated checklist for responding to such a situation; and that the operator's Smoke or Fumes Evacuation checklist should be performed only after the fire has been extinguished or at such time as smoke or fumes become the greatest threat. The guidelines further state that smoke removal may change the airflow and worsen the situation by fanning or masking an ignition source.

Boeing is currently updating the flight and operations manuals for most of its product line to provide revised smoke, fire, and fumes checklists based on the template of the industry initiative. However, Boeing does not currently plan to revise the manuals of older airplanes like the DC-8, which will require individual operators of this airplane to work with the manufacturer and the FAA to develop such revisions for their own operations. Therefore, the need for FAA guidance remains especially important for older airplanes, including the accident airplane model.

If UPS procedures had contained guidance similar to that in the 2004 smoke, fire, and fumes industry checklist, the flight crew would have had a simplified, appropriate procedure to address the problem. Therefore, the Safety Board concludes that the aviation industry initiative on smoke, fire, and fumes provides specific guidance on when and how flight crews should respond to evidence of a fire in the absence of a cockpit smoke and/or fire warning. The Safety Board believes that the FAA should provide clear guidance to operators of passenger and cargo aircraft operating under 14 CFR Parts 121, 135, and 91K on flight crew procedures for responding to evidence of a fire in the absence of a cockpit alert based on the guidance developed by the 2004 smoke, fire, and fumes industry initiative.

2.3 Fire Detection and Growth

The first indication of the fire was the first officer's query to the other crewmembers about the smell of burning wood, which occurred about 20 minutes before the main cargo compartment Cargo Smoke warning light activated, indicating that the fire had been burning for at least that long. However, the flight engineer saw no smoke either of the two times that he visually checked the main cargo compartment. This evidence indicates that the fire initially did not generate a significant amount of smoke and was most likely initiated as a smoldering fire inside a cargo container. The construction of the cargo containers, which results in restricted airflow in or out of the container, likely inhibited the growth and detection of the fire in its initial stages. On the basis of this evidence, the Safety Board concludes that the fire on board the accident airplane initiated as a smoldering fire.

Once the fire breached the cargo container in which it initiated, it would have begun to spread to adjacent containers. Detection of the fire by the main cargo compartment smoke detectors most likely occurred around the time of the first container burnthrough. The smoke detector in lower cargo compartment 33 alerted about 1 minute after the main cargo compartment alert, and some of the captain's displays then began to falter, indicating the continued progression of the fire.

The flight engineer first saw smoke when he exited the cockpit to close the main cargo air shutoff valve and black smoke emanated from the valve's access panel. About 2 minutes later, almost immediately after touchdown, the flight engineer reported that smoke had begun entering the cockpit. The smoke continued to worsen after the airplane came to a stop, and the smoke in the cockpit became so thick that the two pilots could not see each other before evacuating the airplane.

ARFF personnel who entered the airplane through the L1 door observed smoke but no fire in the main cargo compartment. Flames were first observed about 40 minutes after the airplane landed when ARFF personnel opened the right-forward overwing hatch and noticed flames above the containers just aft of the opening. The continued growth of the fire after the airplane landed was probably affected by the introduction of fresh air through the openings in the airplane, both through its open doors and eventually through holes created in the fuselage as the fire ultimately burned through the fuselage crown. The growth of the fire was also affected by the combustible nature of the packages and packing materials in the cargo containers, which provided a readily ignitable fuel source for the growing fire. The fuselage burned through aft of the wings (near containers 12, 13, and 14) about 2 hours after landing.

On the basis of this evidence, the Safety Board concludes that the fire was detected by the airplane's smoke and fire detection system after the fire breached a cargo container, at which time, it proceeded to spread and that the growth of the fire after landing was fed by air entering through open doors and burnthrough holes.

2.4 Origin and Cause of Fire

Despite the length of time that the fire burned and the resulting destruction of potentially helpful evidence, the postfire condition of the cargo containers and contents and the surrounding airplane structure were examined for any evidence indicating the location from which the fire initiated. As a result of these examinations, the lower cargo compartments were eliminated as the origin of the fire because they sustained no heat-related damage, and the outer surfaces of their ceiling liners only exhibited sooting and smoke damage. The fire/smoke detector activations in lower cargo compartments 33 and 34 resulted from smoke infiltrating the lower compartments from the main cargo compartment above this area.

Cargo containers 1 to 11 were eliminated as the fire initiation location because they sustained minimal to moderate thermal damage and the surrounding fuselage sustained little to no structural damage. Further, the ceiling liners were still in place for containers 1 to 7. Although the ceiling liners in containers 8 to 11 sustained thermal damage, it most likely resulted after the overwing hatches were opened. Containers 15 and 18 were eliminated as the fire initiation location because the cargo in these containers was accounted for during the on-scene examination and no evidence of ignition sources was found.

The contents in containers 16 and 17 were heavily damaged, and fuselage burnthoughs were located near both containers. However, containers 16 and 17 were eliminated as the fire initiation location, in part, because the aftward movement of air in flight and on the ground would have made it unlikely that the fire started in either of these containers. Further, the amount of damage sustained near cargo container 17 might have resulted when ARFF personnel opened the L4 and R4 doors soon after they arrived on scene. ARFF personnel indicated that no fire was observed inside the rear of the airplane at this time. Pictures taken soon after the response began do not show any visible fire in that area, but pictures taken 2 hours into the emergency response show this area heavily involved in fire.

Conversely, ARFF personnel did report first observing flames inside the airplane in an area near containers 12 and 13, and this area is also the area above where the first smoke detector activated in the lower cargo compartments. Further, the amount of damage to containers 12, 13, and 14, their contents, and the areas surrounding these containers, including two complete and a partial fuselage burnthrough, indicates that the fire most likely originated in one of these cargo containers. The lowest point of fuselage damage, which could be indicative of the point of origin of the fire, was located in the right aft portion of container 12 near container 13, where the damage extended down to the cargo compartment floor. Container 14 exhibited heavy damage to the contents and was relatively near the areas of the fuselage with the most damage. In addition, a large number of the items in this container were not identified either during the on-scene examination or through the shipper interview calls. As a result, container 14 could not be eliminated as a source of the fire.

No evidence of explosion or high-temperature fire (for example, melted steel components) was found. Several factors eliminated the airplane's wiring as a possible source of the fire, including the lack of any electrical burning odor, the lack of fused wires or damage associated with arcing wires, and the lack of system or display anomalies until almost 20 minutes after the flight crew first detected an odor. Other than secondary lithium batteries, which are discussed below, all of the recovered declared and undeclared hazardous materials were eliminated as ignition sources because they were found intact and relatively undamaged. No additional hazardous or questionable items (that is, undeclared hazardous, chemical, or flammable materials) were identified during the identification effort.

Examinations of the cargo containers and their contents revealed that a number of electronic devices, such as laptop computers, contained some type of power source, specifically secondary lithium cells. All electronic devices and battery packs and cells that had any type of thermal damage were examined on scene; however, most of the items were too damaged for further documentation. Several laptop computers, loose battery cells, and battery packs with severe damage were retained and sent to the Safety Board's laboratory for further examination. During the cargo examinations, no batteries were found that exhibited any damage identifying a source of ignition.

Because the fire most likely originated in cargo container 12, 13, or 14, investigators attempted to determine the contents of the packages that were not accounted for on scene by contacting the shippers of the packages in these containers. This effort was unable to determine the contents of all of the packages in these containers; however, the effort did reveal that several electronic devices likely containing secondary lithium batteries were shipped in these containers. Unfortunately, the lack of information about the devices or the batteries prevented any determination of whether these batteries were associated with previously known recalls. The Safety Board concludes that the exact origin and cause of the in-flight fire on board the airplane could not be determined due to the destruction of potentially helpful evidence; however, the available evidence suggests that the fire most likely originated in container 12, 13, or 14.

2.5 Smoke or Fire Detection System Certification Tests

Because the first smoke detector system activation did not occur until at least 20 minutes after the fire had initiated, the system did not perform in accordance with the performance standards established by the FAA (smoke detector system activation within 5 minutes of fire initiation). The Safety Board's investigation revealed that the smoke detection system certification tests for the DC-8 were not conducted with cargo loaded on the airplane, nor were they required to be, and, therefore, the tests did not account for the effects of a loaded cargo area on smoke detection.

The investigation also revealed that current smoke and fire detection system certification tests do not adequately test for "all approved operating configurations and conditions," as required by 14 CFR 25.858. Although the accident airplane was certificated under CAR 4b, not Part 25, the Safety Board is concerned that current certification methods do not ensure that smoke and fire detection systems are operating in compliance with FAA regulations for smoke detection timeliness.

AC 25-9A contains guidelines on how to conduct certification tests in compliance with FAA regulations and states that the tests should demonstrate that the system can detect a smoldering fire. However, although the AC proposes various acceptable smoke generators and materials to be used in the tests, it does not indicate whether the tests should be conducted with cargo loaded in the cargo compartment or whether cargo containers should be used. Information provided by FAA and Boeing personnel indicates that smoke and fire detection system certification tests are typically conducted with a smoke-generating device in the open area of the compartment, which is more representative of a passenger airplane configuration than a cargo configuration with containers. They indicated that the tests were conducted without cargo containers because using an empty compartment results in greater smoke dilution, requiring the smoke detectors to be sensitive to a small amount of smoke.

With cargo containers loaded in the cargo compartment, air exiting the air conditioning vents in the ceiling is primarily directed outward and downward toward the floor. The cargo containers also create a barrier that the smoke must traverse before it enters the open space of the cargo compartment where it can be detected by the smoke detection system. Neither of the effects of cargo containers—the ventilation changes and the smoke barrier—are accounted for during the certification tests; therefore, the tests do not ensure compliance with the performance criteria contained in 14 CFR 25.858, which requires that all approved operating configurations and conditions be tested.

The Safety Board concludes that the current certification test standards and guidance for smoke and fire detection systems on board many aircraft are not adequate because they do not account for the effects of cargo and cargo containers on airflow around the detection sensors and on the containment of smoke from a fire inside a container. The Board is concerned that a fire producing a small amount of smoke within a sealed cargo container may not be promptly detected by existing smoke detection systems. Therefore, the Safety Board believes that the FAA should ensure that the performance requirements for smoke and fire detection systems on cargo airplanes account for the effects of cargo containers on airflow around the detection sensors and on the containment of smoke from a fire inside a container and should establish standardized methods of demonstrating compliance with those requirements.

2.6 Smoke Detection and Fire Suppression Systems on Cargo Airplanes

The accident airplane was not required to be equipped with a fire suppression system, and, as a result, the fire, which began as a smoldering fire in one of the cargo containers, was able to develop into a substantial fire that burned through the container and ceiling liner while the airplane was airborne. The Safety Board has had longstanding concerns about the lack of fire suppression systems in cargo compartments and has issued several safety recommendations in the last 20 years to address this issue.

For example, as a result of the investigation into the May 11, 1996, accident involving ValuJet flight 592, the Safety Board issued Safety Recommendation A-97-56, which asked the FAA to expedite final rulemaking to require smoke detection and fire suppression systems for all class D cargo compartments. On February 12, 1998, the FAA issued a final rule that required the installation of fire suppression equipment in cargo compartments on board passenger aircraft; however, the requirement for a fire suppression system did not apply to cargo airplanes.

In addition, as a result of its investigation of the September 5, 1996, fire involving FedEx flight 1406, the Safety Board issued Safety Recommendation A-98-78, which asked the FAA to require on-board fire extinguishing systems if they were deemed feasible. In response, the FAA indicated that current procedures regarding ventilation and depressurization were sufficient means to control a fire until the flight could land and that an on-board suppression system would add “considerable” weight to the airplane and reduce the amount of cargo that could be carried on board.

At the UPS flight 1307 public hearing, the FAA indicated that it was considering an NPRM for the development of a new compartment classification, class F, which would require fire detection and suppression systems in which any means of chemical extinguishment and crew access could be used. Class E compartments would continue to be used in all-cargo operations. The FAA acknowledged at the hearing that recent technologies have made fire suppression systems on board cargo airplanes more feasible to operators and that it expects to receive input on new ideas and technologies for fire suppression systems on cargo airplanes as a result of the NPRM. FedEx stated at the public hearing that it has already developed an on-board cargo compartment fire extinguishing system, which testing showed completely extinguished a fire before it breached the container.

The Safety Board commends the actions taken by FedEx to voluntarily develop a fire suppression system for its airplanes. The Safety Board concludes that the threat from cargo fires could be mitigated by the installation of fire suppression systems. Therefore, the Safety Board believes that the FAA should require that fire suppression systems be installed in the cargo compartments of all cargo airplanes operating under 14 CFR Part 121.

As previously mentioned, FAA primary lithium battery flammability tests have concluded that Halon is not an effective means to suppress fires involving primary lithium batteries. Currently, the Safety Board is unaware of any fire suppression system that is effective on primary lithium battery fires. Therefore, although the installation of fire suppression systems in all cargo compartments on cargo-only aircraft, as recommended by the Board, would reduce the risks from a fire involving most cargo items, including secondary lithium batteries, this action would essentially have no effect on a primary lithium battery fire. Further, until such time that fire suppression systems are installed on cargo-only aircraft, secondary lithium batteries will continue to typically be transported in compartments without fire suppression systems.

Therefore, the Safety Board concludes that flight crews on cargo-only aircraft remain at risk from in-flight fires involving both primary and secondary lithium batteries. The Safety Board believes that PHMSA should require aircraft operators to implement measures to reduce the risk of primary lithium batteries becoming involved in fires on cargo-only aircraft, such as transporting such batteries in fire resistant containers and/or in restricted quantities at any single location on the aircraft. The Safety Board further believes that, until fire suppression systems are required on cargo-only aircraft, as asked for in Safety Recommendation A-07-99, PHMSA should require that cargo shipments of secondary lithium batteries, including those contained in or packed with equipment, be transported in crew-accessible locations where portable fire suppression systems can be used.

2.7 Emergency Response Issues

2.7.1 Emergency Response Timeliness

After the flight had been cleared to land on runway 27R, the PHL ATCT local controller changed the landing runway to 27L because it was the runway designated for emergencies at PHL. The captain acknowledged the landing clearance, but he did not specifically acknowledge the runway change. When it became apparent that the airplane was still aligned with runway 27R, the controller provided clearance to land on runway 27R. The local controller notified the PHL ARFF facility of the emergency immediately after being notified by the captain about a cargo smoke indication. ARFF vehicles proceeded to the standby positions for runway 27L. When the clearance was changed to runway 27R, ARFF vehicles moved toward that runway. Although the change in runway caused a 60- to 90-second delay, ARFF personnel arrived on scene about 4 minutes after the initial emergency notification was made and as the flight crew was evacuating the airplane. Therefore, the Safety Board concludes that the emergency response for this accident was timely.

Although the flight crew safely evacuated the airplane and the emergency response was timely, several emergency response-related safety issues were identified during the investigation. Section 2.7.2 discusses a safety issue related to ARFF equipment training, section 2.7.3 discusses a safety issue related to cargo aircraft familiarization training, and section 2.7.4 discusses a safety issue related to cargo airplane emergency exit requirements.

2.7.2 High-Reach Extendable Turret With Skin-Penetrating Nozzle Training for Aircraft Rescue and Firefighting

PHL ARFF personnel used an HRET/SPN during the UPS emergency response in an attempt to pierce the fuselage and fight the interior fire. The ARFF personnel who used the HRET/SPN during the emergency response stated, during postaccident interviews, that they experienced problems penetrating the fuselage with the device and had to reposition the tip of the nozzle a few times before successfully piercing the airplane's fuselage. The emergency response to this accident has not been the only response during which ARFF personnel experienced problems using an HRET/SPN. For example, during the response to the February 2005 runway overrun at Teterboro Airport (TEB), Teterboro, New Jersey,[70] the HRET/SPN operators experienced problems similar to those experienced by the UPS responders. Specifically, the piercing tip folded back and had to be reset during piercing attempts.

In 2005, the FAA conducted research that determined that the HRET/SPN outperformed the standard roof-mounted turret and handline, including the ability to better control and contain the spread of interior fires and reduce high cabin temperatures. FAA and IFSTA training materials state that the successful use of the device depended on the skill level of the operator and required continual training in operations, tactics, and strategies. Although ACs 150/5210-17A and 150/5220-10C state that ARFF personnel should be trained to identify the proper procedures for the use of each hose, nozzle, and adapter used locally and should be provided guidance on equipment training, neither of the ACs specifically address training on the use of the HRET/SPN.

Since PHL ARFF obtained its HRET/SPN in 1991, it has used two different devices to train its ARFF personnel on how to penetrate a fuselage: a small general aviation airplane, which PHL no longer uses, and a SAFT mockup. The HRET/SPN-equipped vehicle at TEB was operated by two police officers who had been cross-trained in ARFF. Both officers stated that they had training on an HRET/SPN-equipped vehicle. One of the officers stated that he thought that the training had helped him during the accident response but that he also believed that "you have to practice every day."

Despite having received some training on the HRET/SPN, ARFF personnel at both PHL and TEB encountered problems using the device. Further, because of aviation's excellent safety record, most ARFF personnel may not have any actual experience fighting

[70] National Transportation Safety Board, *Runway Overrun and Collision, Platinum Jet Management, LLC, Bombardier Challenger CL-600-1A11, N370V, Teterboro, New Jersey, February 2, 2005*, Aircraft Accident Report NTSB/AAR-06/04 (Washington, DC: NTSB, 2006).

an interior fire. The Safety Board notes that the PHL and TEB ARFF personnel who used the HRET/SPN during the emergency responses had never used the device during an actual emergency response up to that time.

The Safety Board concludes that some ARFF personnel are not adequately trained on the use of the HRET/SPN, reducing the effectiveness of the device in fighting interior aircraft fires. Therefore, the Safety Board believes that the FAA should provide guidance to ARFF personnel on the best training methods to obtain and maintain proficiency with the HRET/SPN.

2.7.3 Aircraft Rescue and Firefighting Cargo Familiarization Training

Although PHL's AEP required ARFF personnel to respond to all accidents at the airport, PHL ARFF did not typically conduct aircraft familiarization training on cargo aircraft before the accident, and ARFF personnel were not familiar with the accident airplane. During the emergency response, PHL ARFF personnel had problems opening the main cargo door, most likely because they did not understand its manual operation. Specifically, one of the responders broke the exterior cargo door handle when he tried to force it open and rendered it inoperable. As a result, PHL ARFF personnel were unable to off-load cargo containers, which affected their ability to locate, access, and suppress the fire. Similar problems were noted in the Safety Board's report on the September 5, 1996, Newburgh, New York, accident, which indicated that ARFF personnel were also not familiar with the operation of the main cargo door and initially were unable to open it.

In accordance with 14 CFR 139.139(i), ARFF personnel are required to receive initial and recurrent training in 12 subject areas. AC 150/5210-17A, "Programs for Training of Aircraft Rescue and Firefighting Personnel," provides guidance on how to meet the regulations and specifies what should be included in the training program for aircraft familiarization. The AC recommends that ARFF personnel be trained to "identify the types of aircraft operating at the airport . . . [and] locate normal entry doors [and] emergency exit openings." Although neither the regulations nor the AC excludes cargo airplanes from aircraft familiarization training for ARFF personnel, evidence from the UPS and Newburgh accident investigations indicates that some airports do not provide such training and that such training is needed to facilitate emergency response efforts.

The Safety Board concludes that PHL ARFF personnel were not familiar with the accident airplane's main cargo door, which adversely affected their ability to access the airplane's interior to fight the fire. Even though PHL has substantial cargo operations and an AEP that requires the airport to respond to all on-site accidents, PHL ARFF personnel indicated that they did not schedule familiarization training on cargo aircraft. Although the Board is encouraged that PHL ARFF has initiated cargo familiarization training since the accident, it is concerned that cargo aircraft familiarization training may not be emphasized at other airports. Therefore, the Safety Board believes that the FAA should require airport inspectors to ensure that

Part 139 airports with cargo operations include cargo aircraft in their ARFF aircraft familiarization training programs.

A review of the DC-8 Emergency Response diagrams that UPS provided to PHL ARFF after the accident found that they included information on locating and opening exits and cargo doors; however, the diagrams were not accurate or complete. For example, no information was provided about the main cargo door's vent door, including the fact that the vent door had to be opened before the cargo door could be opened. Further, the diagrams incorrectly identified the aft overwing hatches as operational and incorrectly noted that the doors contained external contrasting colors to help ARFF personnel locate the doors.

The Safety Board concludes that the availability of accurate and complete airplane diagrams would improve ARFF personnel's knowledge and familiarity with fleet configurations and would facilitate emergency response operations. Accordingly, the Safety Board believes that the Cargo Airline Association[71] should work with its member airlines and other groups, such as the Air Transport Association, major aircraft manufacturers, and the ARFF Working Group,[72] to develop and disseminate accurate and complete airplane Emergency Response diagrams for ARFF personnel at airports with cargo operations.

2.7.4 Cargo Airplane Emergency Exit Requirements

The accident airplane's two side cockpit windows had been designated as the airplane's emergency exits. The L1 door, which was used as the primary means of entry and exit for the airplane, was also identified as an emergency exit in the UPS DC-8 AOM and on the airplane's emergency briefing card.

Although the two cockpit windows provide one means of flight crew emergency egress from the airplane, a floor level emergency exit provides an additional egress point. Further, although cargo aircraft do not carry passengers, Federal regulations allow cargo operators to carry additional personnel.[73] The accident airplane was configured to carry up to 7 occupants, and the Safety Board has learned that some cargo operators' wide-body airplanes can be configured to carry up to 27 occupants.[74] Although the two cockpit windows provide a means for the flight crew to evacuate the airplane, a floor level emergency exit with an evacuation slide would provide a more efficient and expedient way for all occupants to exit a cargo airplane in the event of an emergency.

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71 The Cargo Airline Association is an association for members of the all-cargo air carrier industry.

72 The ARFF Working Group is an association that promotes the improvement of the methods of aviation fire protection and prevention.

73 Title 14 CFR 121.583 allows cargo operators to carry additional personnel, including, but not limited to, additional crewmembers, company or government personnel, and other individuals necessary for the safety of flight or monitoring the cargo.

74 An FAA CertAlert dated January 21, 2004, regarding an accident involving an MD-10 cargo airplane noted that ARFF personnel responding to the scene were surprised to see seven people exit the airplane. The alert stated that as many as 27 personnel could be on board the operator's MD-10 airplanes at any time.

In addition, ARFF personnel may also need to enter an airplane to rescue occupants, fight a fire, or search for the NOTOC. A floor level exit provides ARFF personnel with the most efficient means to enter an airplane wearing protective gear or breathing apparatus that could prevent their entry through a cockpit window. Further, as seen in the UPS and the Newburgh, New York, cargo accidents, ARFF personnel may need to access the area inside the L1 door to manually operate the main cargo door. If the L1 door were a designated emergency exit, it would be required to have instructional placards. Although ARFF personnel did not open the L1 door during this emergency response, instructional placards would benefit ARFF personnel as well as other first responders (such as mutual aid, ramp personnel, and airport operations).

The FAA acknowledged that, although a forward floor level emergency exit is not required on cargo airplanes, operators often designate the L1 door as an alternate emergency exit. Further, as evidenced by the UPS and FedEx accidents, even if the cockpit window exits are accessible, the floor level exit is often the preferred emergency exit for use by occupants to egress the airplane under emergency conditions. The Safety Board is concerned that the L1 door is not required to be designated as an "emergency exit" despite evidence that floor level exits are often used by cargo airplane occupants in the event of an emergency and provide a faster and more efficient means for the flight crew and other occupants to exit the airplane.

At the time of the DC-8's certification, Federal regulations required emergency exits and their means of opening to be marked on the outside of the airplane to assist ARFF personnel. Although the cockpit windows had exterior placards providing instructions on their operation, they were not visually identifiable as emergency exits because they had no contrasting colored band around them nor were they required to be by Federal regulations. Further, the L1 door did not have either exterior instructional placards or a visual indication that it was an emergency exit. The Safety Board is concerned that cargo airplane emergency exits are not required to have visual markings indicating them as emergency exits even though such markings are required on passenger airplanes and would provide ARFF with a rapid method of identifying such exits.

Therefore, the Safety Board concludes that a floor level emergency exit, including one equipped (when appropriate) with an evacuation slide, would enable more efficient emergency egress for airplane occupants than cockpit window exits and that the associated, instructional placarding of such an exit would assist emergency responders with locating and operating the exit door and accessing the interior of the airplane. Therefore, the Safety Board recommends that the FAA require cargo operators to designate at least one floor level door as a required emergency exit and equip the door with an evacuation slide, when appropriate. Further, the Safety Board recommends that the FAA require all emergency exits on cargo aircraft that are operable from the outside to have a 2-inch contrasting colored band outlining the exit.

2.8 Retrieval and Dissemination of Hazardous Materials Information

The captain and first officer were not able to find the NOTOC, which contained information on the hazardous materials on board the airplane, during the evacuation because of the smoke in the cockpit and because they did not know that the flight engineer had moved it. ARFF personnel who entered the cockpit after the evacuation were also unable to locate the NOTOC. When asked for the hazardous materials information, the UPS ramp supervisor stated that he could only provide the locations of the hazardous materials, not their identity, and that the NOTOC on board the airplane was the only source he was aware of that contained this information. About 40 minutes after the airplane landed, ARFF personnel reentered the airplane without knowing whether any potential safety hazards existed, found the NOTOC, and provided it to the incident commander.

According to UPS management, in the event of an emergency, airport ground personnel were supposed to contact the UPS Flight Control Group in Louisville, Kentucky, to obtain specific information related to hazardous materials on board UPS flights from the HMIS. However, UPS ground personnel at PHL did not contact the UPS Flight Control Group on the day of the accident. Although the HMIS was on line at PHL, UPS ground personnel were only authorized to access information about the quantity and locations of hazardous materials, not their identity. According to Flight Control personnel, once they heard about the accident, they retrieved the hazardous materials information for the flight from the HMIS; however, Flight Control did not provide this information to PHL Airport Operations or UPS ground or ARFF personnel. Additionally, both Airport Operations and ARFF personnel requested the hazardous information from UPS ground personnel at PHL; however, UPS ground personnel did not have access to the electronic system containing the desired information and did not contact UPS Flight Control in Louisville to obtain a copy of it.

Although emergency responders eventually located the NOTOC on the airplane and ARFF efforts were not significantly delayed, UPS personnel's failure to quickly access specific hazardous materials information and provide it to ARFF personnel could have potentially created a safety hazard. The Safety Board concludes that UPS guidance on hazardous materials information retrieval and dissemination was inadequate, which resulted in UPS personnel not providing emergency responders with detailed information about the hazardous materials on board the airplane in a timely manner.

Since the accident, UPS has revised its operations manuals to clarify personnel reporting responsibilities and the role and capabilities of Flight Control, promoting a more proactive approach to emergency response and hazardous materials communication. However, although these changes are an improvement and should result in hazardous materials information being provided in a timelier manner, the Safety Board is concerned that other operators might not have adequate guidance on hazardous materials information dissemination. The Board has previously addressed the importance of providing detailed hazardous materials information to emergency responders in a timely manner in its investigation of the in-flight fire and emergency landing in Newburgh, New York. The investigation revealed that emergency responders did not receive specific information concerning the identity of hazardous materials, their quantities, or the number of packages on the airplane during the firefighting phase of the emergency. Although the unavailability of such information did not affect firefighting efforts, the overall importance of the timeliness in which emergency responders receive specific information about hazardous materials and the potential implications of unawareness were emphasized in the Board's report.

In the Newburgh report, the Safety Board noted that shipping documents are inherently at risk of destruction by fire and that flight crewmembers would most likely be unable to retrieve such paperwork because of the dangers of on-board fire, leaving it to the operator to provide the information to emergency responders. At the time of the Newburgh accident, Federal regulations did not adequately address the need for hazardous materials information on file with an air carrier to be quickly retrievable in a format useful to emergency responders. As a result, the Board issued Safety Recommendation A-98-80 to RSPA, proposing that it require air carriers to have a means to quickly retrieve and provide consolidated, specific hazardous materials information to emergency responders, 24 hours per day.

In response, on March 25, 2003, RSPA published a final rule, which revised 49 CFR 175.33 to mandate that air carriers have a copy of the NOTOC at the departure and intended arrival airports and, upon request, make the information available to emergency responders. In an August 18, 2003, letter, the Safety Board stated that it was pleased that RSPA had made it a requirement that hazardous materials information be made available immediately upon request but that it was disappointed that the revision did not address the need for providing such information in a consolidated format. Consequently, the Board classified Safety Recommendation A-98-80 "Closed—Unacceptable Action."

Because 49 CFR 175.33(d) requires air carriers to make a copy of the NOTOC information available to emergency responders "upon request," the regulatory requirement suggests that the voluntary transfer of hazardous materials information, without a formal request, is optional for the carrier. In contrast, the ICAO document, "Technical Instructions for the Safe Transport of Dangerous Goods by Air," provides the following guidance on the transfer of hazardous materials information between aircraft operators and emergency personnel:

> In the event of an aircraft accident or serious incident, the operator of an aircraft carrying dangerous goods as cargo must provide information, without delay, to emergency services responding to the accident or serious incident about the dangerous goods on board, as shown on the copy of the information to the pilot-in-command.

The ICAO document promotes a proactive approach to the transfer of hazardous materials information during an emergency, which improves the likelihood that this information will get to emergency responders in a timely manner. In the case of this accident, UPS Flight Control personnel's actions satisfied the intent of the requirements as they are written. Flight Control had the on-board hazardous materials information readily available; however, they stated that they did not volunteer the information because they did not receive a request for it, therefore, they were not obligated to volunteer it, as stipulated by the regulations.

The Safety Board concludes that the requirements of 49 CFR 175.33(d) are not adequate because they do not require operators to provide hazardous materials information to emergency responders immediately upon notification of an accident. Therefore, the Safety Board believes that PHMSA should require aircraft operators that transport hazardous materials to immediately provide consolidated and specific information about hazardous materials on board an aircraft, including proper shipping name, hazard class, quantity, number of packages, and location, to on-scene emergency responders upon notification of an accident or incident.

2.9 Air Transport of Lithium Batteries

Although it could not be determined whether lithium batteries played a role in the UPS cargo fire, public hearing testimony and the continued occurrence of incidents involving these batteries on board airplanes suggest the need for greater attention to the risks posed by transporting these batteries on commercial aircraft. A review of FAA and CPSC records shows that the number of both secondary and primary lithium battery-related incidents (many of which involved laptop computer fires that resulted from either internal or external short-circuiting of the secondary lithium batteries) has increased consistently over the years.[75] Since February 2006, the CPSC has recalled more than 9 million laptops containing secondary lithium batteries and has issued additional recalls for other products containing secondary lithium batteries. During the Safety Board's public hearing, the CPSC predicted that more incidents and recalls would occur if the deficiencies were not addressed. Further, the increasing popularity of portable electronic devices suggests that lithium battery-related incidents, particularly those involving secondary lithium batteries, will continue to increase. The Safety Board concludes that testing and incident data indicate that lithium batteries can pose a fire hazard.

In response to recent secondary lithium battery-related incidents and issues addressed during the Safety Board's public hearing, the FAA, ALPA, and PHMSA all issued safety alerts or advisories in 2007, which addressed smoke and fire hazards, recommended crew actions in the event of a battery fire, the availability of guidance for the safe transport of batteries and battery-powered devices on board aircraft, and proper packing and handling procedures for these batteries.

On August 9, 2007, PHMSA issued new requirements that tightened the safety standards governing the air transportation of both primary and secondary lithium batteries. The final rule prohibits the transport of primary lithium batteries and cells as cargo on passenger-carrying aircraft. Additionally, spare lithium batteries can only be transported

[75] Incidents involving small secondary battery-related incidents are not required to be reported, and the reporting level might have increased, in part, as a result of greater awareness of the hazards associated with these batteries.

as carry-on items. Further, the exemptions for medium primary and secondary lithium batteries were eliminated, and new marking paperwork requirements were added for those batteries transported as cargo by air or vessel.

The new requirements in the August 2007 rulemaking address the comments in the Safety Board's September 26, 2002, letter to PHMSA regarding Safety Recommendations A-99-80 and -82. The rulemaking also addresses Safety Recommendation A-99-85 to the FAA. Under this rule, on the basis of the FAA's initial testing of the fire risks posed by secondary lithium batteries and PHMSA's elimination of many of the exemptions for primary and secondary lithium batteries, greater shipments of lithium batteries will be transported by air as declared hazardous materials that will be required to comply with enhanced packaging and identification standards. Therefore, the Safety Board classifies Safety Recommendations A-99-80, -82, and -85 "Closed—Acceptable Action."

The issuance of the safety alerts and advisories and the new, more stringent requirements demonstrate the growing awareness and concern within the DOT and the airline industry over the air transportation of primary and secondary lithium batteries and electronic equipment containing such batteries. These initiatives will also heighten awareness about the common risks associated with both primary and secondary lithium batteries. Although the Safety Board is encouraged by these efforts, other concerns still remain.

The FAA currently maintains records of aviation incidents involving batteries and battery-powered devices, including those involving primary and secondary lithium batteries. The records likely do not provide a complete listing because many of the incidents involved lithium batteries that were exempted from incident reporting requirements. As a result, many operators have most likely not reported similar incidents. In addition, although PHMSA's August 2007 final rule includes a marking and paperwork requirement for small secondary and primary cells and batteries, the new requirement only applies to packages containing 24 or more cells or 12 or more batteries and does not include batteries packed with or contained in equipment. As a result, shipments of batteries and electronic equipment with fewer than 24 cells or 12 batteries, such as laptop computers, are still exempt from reporting requirements, and, therefore, incidents involving such shipments are likely to remain largely unreported.

Consequently, the Safety Board concludes that, because many incidents involving lithium batteries are exempt from reporting requirements, the data regarding such incidents are incomplete, which has prevented a thorough assessment of the causes of these failures and the risks associated with transporting lithium batteries. Therefore, the Safety Board believes that PHMSA should require commercial cargo and passenger operators to report to PHMSA all incidents involving primary and secondary lithium batteries, including those contained in or packed with equipment, that occur either on board or during loading or unloading operations and retain the failed items for evaluation purposes. The Board also remains concerned that the causes of secondary lithium battery failures are not well understood or documented. This may be due, in part, to the fact that proper evaluation of failed lithium batteries is not always performed and that, in many cases, these batteries are disposed of before the incident is reported, precluding an accurate analysis of the failures. Regarding primary lithium batteries, although it is understood that physical damage and exposure to heat and fire are major concerns, the impact of clustering several thousand primary batteries on a single pallet or in a single cargo container has not been considered or evaluated. Given that Halon is not an effective suppressant for a primary lithium battery fire, the risk of battery involvement in any type of fire needs to be determined.

Analyzing future secondary and primary lithium battery-related incidents should help determine the causes of the failures and, in turn, allow the most appropriate transportation requirements to be established. Therefore, the Safety Board concludes that an in-depth analysis of the causes of secondary and primary lithium battery failures would improve the safe transportation of these batteries. Therefore, the Safety Board believes that PHMSA should analyze the causes of all thermal failures and fires involving secondary and primary lithium batteries and, based on this analysis, take appropriate action to mitigate any risks determined to be posed by transporting lithium batteries, including those contained in or packed with equipment, on board cargo and passenger aircraft as cargo; checked baggage; or carry-on items.

The Safety Board is also concerned about the remaining exemptions for small secondary lithium batteries, such as those used to power laptop computers, cameras, cell phones, and other personal electronic devices, which are allowed to be shipped on passenger and cargo aircraft even though these types of batteries have been involved in at least nine aviation incidents. Cargo shipments of small secondary lithium batteries should be subject to the same packaging and identification requirements that apply to medium and large secondary lithium batteries to increase general awareness of the risks of these batteries and to alert package handlers to exercise greater care when loading and unloading packages containing lithium batteries.

Until the causes of the failures of secondary lithium batteries are understood and effectively addressed, the prudent course of action is to eliminate these exceptions, particularly with respect to packaging and identification. Therefore, the Safety Board concludes that PHMSA's August 2007 final rule regarding the transportation of lithium batteries did not establish sufficient levels of safety for air transportation of small secondary lithium batteries (no more than 8 g equivalent lithium content). Therefore, the Safety Board believes that PHMSA should eliminate regulatory exemptions for the packaging, marking, and labeling of cargo shipments of small secondary lithium batteries (no more than 8 g equivalent lithium content) until the analysis of the failures and the implementation of risk-based requirements asked for in Safety Recommendation A-07-108 are completed.

3. Conclusions

3.1 Findings

1. The flight crewmembers were properly certificated and qualified under Federal regulations. No evidence indicated any preexisting medical or physical condition that might have adversely affected the flight crew's performance during the accident flight.

2. No evidence was found indicating that fatigue degraded the performance of any of the flight crewmembers on the day of the accident.

3. Examinations of the recovered components revealed no evidence of any preexisting powerplant, structural, or system failures.

4. The flight crew's continued descent to Philadelphia International Airport was not inappropriate given that there was no evidence of abnormalities other than the odor and that no cockpit alerts had activated.

5. The increased airflow that resulted from the Fumes Evacuation checklist actions diluted the smoke and inhibited its detection by either the smoke detection system or flight crewmembers and provided the fire with additional oxygen.

6. The aviation industry initiative on smoke, fire, and fumes provides specific guidance on when and how flight crews should respond to evidence of a fire in the absence of a cockpit smoke and/or fire warning.

7. The fire on board the accident airplane initiated as a smoldering fire.

8. The fire was detected by the airplane's smoke and fire detection system after the fire breached a cargo container, at which time, it proceeded to spread, and the growth of the fire after landing was fed by air entering through open doors and burnthrough holes.

9. The exact origin and cause of the in-flight fire on board the airplane could not be determined due to the destruction of potentially helpful evidence; however, the available evidence suggests that the fire most likely originated in container 12, 13, or 14.

10. The current certification test standards and guidance for smoke or fire detection systems on board many aircraft are not adequate because they do not account for the effects of cargo and cargo containers on airflow around the detection sensors and on the containment of smoke from a fire inside a container.

11. The threat from cargo fires could be mitigated by the installation of fire suppression systems.

12. Flight crews on cargo-only aircraft remain at risk from in-flight fires involving both primary and secondary lithium batteries.

13. The emergency response for this accident was timely.

14. Some aircraft rescue and firefighting personnel are not adequately trained on the use of the high-reach extendable turret with skin-penetrating nozzle, reducing the effectiveness of the device in fighting interior aircraft fires.

15. Philadelphia International Airport aircraft rescue and firefighting personnel were not familiar with the accident airplane's main cargo door, which adversely affected their ability to access the airplane's interior to fight the fire.

16. The availability of accurate and complete airplane diagrams would improve aircraft rescue and firefighting personnel's knowledge and familiarity with fleet configurations and would facilitate emergency response operations.

17. A floor level emergency exit, including one equipped (when appropriate) with an evacuation slide, would enable more efficient emergency egress for airplane occupants than cockpit window exits, and the associated, instructional placarding of such an exit would assist emergency responders with locating and operating the exit door and accessing the interior of the airplane.

18. United Parcel Service Company (UPS) guidance on hazardous materials information retrieval and dissemination was inadequate, which resulted in UPS personnel not providing emergency responders with detailed information about the hazardous materials on board the airplane in a timely manner.

19. The requirements of 49 *Code of Federal Regulations* 175.33(d) are not adequate because they do not require operators to provide hazardous materials information to emergency responders immediately upon notification of an accident.

20. Testing and incident data indicate that lithium batteries can pose a fire hazard.

21. Because many incidents involving lithium batteries are exempt from reporting requirements, the data regarding such incidents are incomplete, which has prevented a thorough assessment of the causes of these failures and the risks associated with transporting lithium batteries.

22. An in-depth analysis of the causes of secondary and primary lithium battery failures would improve the safe transportation of these batteries.

23. The Pipeline and Hazardous Materials Safety Administration's August 2007 final rule regarding the transportation of lithium batteries did not establish sufficient levels

of safety for air transportation of small secondary lithium batteries (no more than 8 grams equivalent lithium content).

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was an in-flight cargo fire that initiated from an unknown source, which was most likely located within cargo container 12, 13, or 14. Contributing to the loss of the aircraft were the inadequate certification test requirements for smoke and fire detection systems and the lack of an on-board fire suppression system.

4. Safety Recommendations

4.1 New Safety Recommendations

As a result of its investigation of the February 7, 2006, accident involving United Parcel Service Company flight 1307, the National Transportation Safety Board makes the following recommendations to the Federal Aviation Administration:

> Provide clear guidance to operators of passenger and cargo aircraft operating under 14 *Code of Federal Regulations* Parts 121, 135, and 91K on flight crew procedures for responding to evidence of a fire in the absence of a cockpit alert based on the guidance developed by the 2004 smoke, fire, and fumes industry initiative. (A-07-97)
>
> Ensure that the performance requirements for smoke and fire detection systems on cargo airplanes account for the effects of cargo containers on airflow around the detection sensors and on the containment of smoke from a fire inside a container, and establish standardized methods of demonstrating compliance with those requirements. (A-07-98)
>
> Require that fire suppression systems be installed in the cargo compartments of all cargo airplanes operating under 14 *Code of Federal Regulations* Part 121. (A-07-99)
>
> Provide guidance to aircraft rescue and firefighting personnel on the best training methods to obtain and maintain proficiency with the high-reach extendable turret with skin-penetrating nozzle. (A-07-100)
>
> Require airport inspectors to ensure that Part 139 airports with cargo operations include cargo aircraft in their aircraft rescue and firefighting aircraft familiarization training programs. (A-07-101)
>
> Require cargo operators to designate at least one floor level door as a required emergency exit and equip the door with an evacuation slide, when appropriate. (A-07-102)
>
> Require all emergency exits on cargo aircraft that are operable from the outside to have a 2-inch contrasting colored band outlining the exit. (A-07-103)

As a result of this investigation, the National Transportation Safety Board makes the following recommendations to the Pipeline and Hazardous Materials Safety Administration:

Require aircraft operators to implement measures to reduce the risk of primary lithium batteries becoming involved in fires on cargo-only aircraft, such as transporting such batteries in fire resistant containers and/or in restricted quantities at any single location on the aircraft. (A-07-104)

Until fire suppression systems are required on cargo-only aircraft, as asked for in Safety Recommendation A-07-99, require that cargo shipments of secondary lithium batteries, including those contained in or packed with equipment, be transported in crew-accessible locations where portable fire suppression systems can be used. (A-07-105)

Require aircraft operators that transport hazardous materials to immediately provide consolidated and specific information about hazardous materials on board an aircraft, including proper shipping name, hazard class, quantity, number of packages, and location, to on-scene emergency responders upon notification of an accident or incident. (A-07-106)

Require commercial cargo and passenger operators to report to the Pipeline and Hazardous Materials Safety Administration all incidents involving primary and secondary lithium batteries, including those contained in or packed with equipment, that occur either on board or during loading or unloading operations and retain the failed items for evaluation purposes. (A-07-107)

Analyze the causes of all thermal failures and fires involving secondary and primary lithium batteries and, based on this analysis, take appropriate action to mitigate any risks determined to be posed by transporting lithium batteries, including those contained in or packed with equipment, on board cargo and passenger aircraft as cargo; checked baggage; or carry-on items. (A-07-108)

Eliminate regulatory exemptions for the packaging, marking, and labeling of cargo shipments of small secondary lithium batteries (no more than 8 grams equivalent lithium content) until the analysis of the failures and the implementation of risk-based requirements asked for in Safety Recommendation A-07-108 are completed. (A-07-109)

As a result of this investigation, the National Transportation Safety Board makes the following recommendation to the Cargo Airline Association:

Work with your member airlines and other groups, such as the Air Transport Association, major aircraft manufacturers, and the Aircraft Rescue and Firefighting (ARFF) Working Group, to develop and disseminate accurate and complete airplane Emergency Response diagrams for ARFF personnel at airports with cargo operations. (A-07-110)

4.2 Previously Issued Safety Recommendations Resulting From This Accident Investigation

As a result of its investigation of this accident, the Safety Board issued the following safety recommendation to the Federal Aviation Administration on September 25, 2006:

> Amend Federal Aviation Administration Order 7110.65, "Air Traffic Control," to require that, when amending a runway assignment, controllers provide a specific instruction to the pilot advising of the runway change. For example, "UPS 1307, change to runway 25L, cleared to land." (A-06-65)

Safety Recommendation A-06-65 is classified "Open–Unacceptable Response" in this report. For additional information about this safety recommendation, see section 1.18.2.

4.3 Previously Issued Safety Recommendations Classified in this Report

As a result of the April 28, 1999, fire that destroyed freight, including lithium batteries, on two aircraft cargo pallets at a Northwest Airlines cargo facility, the Safety Board issued the following safety recommendations to the Research and Special Programs Administration on November 16, 1999:

> With the Federal Aviation Administration, evaluate the fire hazards posed by lithium batteries in an air transportation environment and require that appropriate safety measures be taken to protect aircraft and occupants. The evaluation should consider the testing requirements for lithium batteries in the United Nations' *Transport of Dangerous Goods Manual of Tests and Criteria*, the involvement of packages containing large quantities of tightly packed batteries in a cargo compartment fire, and the possible exposure of batteries to rough handling in an air transportation environment, including being crushed or abraded open. (A-99-80)

> Require that packages containing lithium batteries be identified as hazardous materials, including appropriate marking and labeling of the packages and proper identification in shipping documents, when transported on aircraft. (A-99-82)

The Safety Board also issued the following safety recommendation to the Federal Aviation Administration on November 16, 1999:

> With the Research and Special Programs Administration, evaluate the fire hazards posed by lithium batteries in an air transportation environment and require that appropriate safety measures be taken to protect aircraft and occupants. The evaluation should consider the testing requirements

> for lithium batteries in the United Nations' *Transport of Dangerous Goods Manual of Tests and Criteria*, the involvement of packages containing large quantities of tightly packed batteries in a cargo compartment fire, and the possible exposure of batteries to rough handling in an air transportation environment, including being crushed or abraded open. (A-99-85)

Safety Recommendations A-99-80, -82, and -85 (previously classified "Open—Acceptable Response") are classified "Closed—Acceptable Action" in this report. These classifications are discussed in section 2.9 of this report.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

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Adopted: December 4, 2007

5. Appendixes

Appendix A

Investigation and Public Hearing

Investigation

The National Transportation Safety Board was initially notified about this accident on February 8, 2006. A full go-team was assembled in Washington, D.C., and traveled to the accident scene. The go-team was accompanied by former Member Ellen Engleman Connors and Member Kathryn O'Leary Higgins.

The following investigative groups were formed: Operations, Maintenance Records, Aircraft Systems, Cargo/Fire, Hazardous Materials, Airport and Survival Factors, Human Performance. While the investigative teams were in Philadelphia, specialists were assigned to conduct the readout of the flight data recorder and to transcribe the cockpit voice recorder at the Safety Board's laboratory in Washington, D.C.

Parties to the investigation were the Federal Aviation Administration (FAA), United Parcel Service Company (UPS), Pipeline and Hazardous Materials Safety Administration (PHMSA), Boeing Commercial Airplane Group, Independent Pilots Association (IPA), and the City of Philadelphia.

Public Hearing

A public hearing was held for this accident on July 12 and 13, 2006, in Washington, D.C. Member Deborah Hersman presided over the hearing.

The issues presented at the public hearing were airport rescue and firefighting response; design, testing, and failure modes of lithium batteries; operations and regulations concerning lithium batteries; and aircraft fire detection and suppression systems and regulations. Parties to the public hearing were the FAA, UPS, Boeing, PHMSA, IPA, and the City of Philadelphia.

Appendix B

Cockpit Voice Recorder Transcript

The following is the transcript of the Fairchild Model A-100 cockpit voice recorder, serial number 928, installed on a Douglas DC-8-71F that landed at Philadelphia International Airport, Philadelphia, Pennsylvania, on February 7, 2006, after reporting a cargo smoke indication.

LEGEND	
CAM	Cockpit area microphone voice or sound source
RDO	Radio transmissions from N748UP
CTR	Radio transmission from ATC center controller
APR	Radio transmission from the Philadelphia approach controller
TWR	Radio transmission from the Philadelphia Local East airport tower controller
O2	Transmission using oxygen mask
RO2	Radio transmission using oxygen mask
A10	Airport 10, Philadelphia Airport Duty Officer
ARFF	Airport Rescue and Firefighting
-1	Voice identified as the Captain
-2	Voice identified as the First Officer
-3	Voice identified as the Second Officer
-?	Voice unidentified
-A	Radio transmission from Atlanta center
-B	Radio transmission from first controller at Washington center
-C	Radio transmission from second controller at Washington center
*****	Unintelligible word
@	Non-pertinent word
[ ]	Editorial insertion

Note 1: Times are expressed in eastern standard time (EST).

Note 2: Generally, only radio transmissions to and from the accident aircraft were transcribed.

Note 3: Words shown with excess vowels, letters, or drawn out syllables are a phonetic representation of the words as spoken.

Note 4: A non-pertinent word, where noted, refers to a word not directly related to the operation, control or condition of the aircraft.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2328:28 START of RECORDING			
START of TRANSCRIPT			
2328:29 CAM-1	we went down to *.		
		2328:30 CTR-A	UPS thirteen oh seven contact Washington center on one two six point eight seven.
		2328:35 RDO-1	two six seven UPS thirteen oh seven good day.
		2328:38 CTR-A	good day.
		2328:59 RDO-1	and Washington good day its ups thirteen zero seven with you level three three zero.
		2329:03 CTR-B	UPS thirteen zero seven Washington center roger cleared direct Woodstown direct Philly.
		2329:07 RDO-1	direct Woodstown direct Philly UPS thirteen oh seven.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2329:14 CAM-?	* O-O-D.		
2330:04 CAM-2	well that was nice of 'em.		
2330:06 CAM-1	yes.		
		2330:30 CTR-B	UPS thirteen oh seven descend at pilot's discretion to flight level two four zero.
		2330:35 RDO-1	discretion two four zero UPS thirteen oh seven.
2330:44 CAM-2	two four zero.		
2330:45 CAM-1	cleared.		
2332:33 CAM	[non-pertinent conversation between three crew members regarding Jet Blue stocks and company until 2334:39.]		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
		2333:44 RDO-1	eh Washington eh UPS thirteen oh seven is out of three three zero for two four zero.
		2333:49 CTR-B	UPS thirteen oh seven roger thank you.
2334:39 CAM-2	smells like wood burning smell that?		
2334:42 CAM-3	** yeah.		
2334:43 CAM-3	I smelled it for a couple of seconds.		
2334:45 CAM-?	***.		
2335:03 CAM	[sound similar to increase in air noise]		
2335:40 CAM-2	its pretty strong now.		
2335:43 CAM-1	**.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
2335:49 CAM	[sound similar to cockpit door or seat operating]		
2335:54 CAM-3	its more in the back.		
2336:01 CAM-2	* temp.		
2336:04 CAM-1	no eh yeah it was a little in the yellow but uh.		
2336:08 CAM-2	what were you looking at?		
2336:12 CAM-1	I was looking at it at one of the high.		
2336:13 CAM-2	manifold temp?		
2336:15 CAM-1	high stage was on.		
2336:20 CAM-1	on one side.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
		2336:23 CTR-B	UPS thirteen oh seven contact Washington center one two five point four five.
		2336:28 RDO-1	two five four five UPS thirteen oh seven thank you.
		2336:31 CTR-B	good day.
2336:39 CAM-1	you might try turning like a pack off uh @ see if that makes any difference.		
		2337:18 RDO-1	uh center good day its uh UPS thirteen oh seven with you passing two seven five for two four zero.
		2337:23 CTR-C	UPS thirteen oh seven Washington center roger.
2338:58 CAM	[sound of tone similar to altitude alert]		
2339:00 CAM-2	twenty five twenty four.		
2339:01 CAM-1	twenty five twenty four.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2339:16 CAM-?	why would it *.		
2339:17 CAM-2	smell like wood.		
2339:19 CAM-3	yeah it does smell like wood.		
2339:22 CAM-3	it doesn't smell electrical smells *.		
2339:25 CAM-1	uh.		
2339:26 CAM-2	that's just duct that's just duct work but there's no wood.		
2339:30 CAM-1	yeah.		
2339:30 CAM-2	there's no brace around any of that stuff is there?		
2339:34 CAM-1	no.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2339:36 CAM-2	like a wood burning kit.		
2340:30 CAM-1	might need to increase that flow on the left side @.		
		2341:04 CTR-C	UPS thirteen oh seven cross ten miles south of Woodstown at and maintain one one thousand Philly altimeter three zero zero five.
		2341:11 RDO-1	ten south of Woodstown at one one thousand UPS thirteen oh seven.
2343:18 CAM-1	might try those bleeds uh switches too @.		
2343:22 CAM-3	*** fume evacuation.		
2343:26 CAM-1	yeah.		
2343:27 CAM-3	said put the pack to max flow.		
2343:28 CAM-1	okay.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2343:29 CAM-3	set pack to max flow.		
2343:32 CAM-3	recirc fan off? recirc fan off.		
2343:34 CAM-1	it may be coming from one of those bleeds you know.		
2343:46 CAM-2	I got go around set in there.		
2343:53 CAM-2	visual backed up with the I-L-S two seven right one oh eight ninety five eleven touchdown zone * * *.		
2344:06 CAM-?	***.		
2344:09 CAM-2	three zero zero five approach check.		
2344:14 CAM-3	approach checklist. pressurization set.		
2344:20 CAM-3	reverser shut off switch?		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2344:22 CAM-1	open.		
2344:22 CAM-3	P-T-C?		
2344:23 CAM-1	override retracted.		
2344:25 CAM-3	airspeed bugs?		
2344:27 CAM-1	thirty nine set.		
2344:29 CAM-3	N one bugs.		
2344:31 CAM-?	*.		
		2344:34 CTR-C	UPS thirteen oh seven contact Philly approach one two four point three five.
2344:38 CAM-2	thirty nine set.		
		2344:39	

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
		RDO-1	two four three five ups thirteen oh seven good day.
		2344:42 CTR-C	good day.
2344:45 CAM-1	eighty seven one set.		
2344:48 CAM-3	okay. approach brief?		
2344:49 CAM-2	complete.		
2344:50 CAM-3	altimeter?		
2344:52 CAM-1	thirty oh five set.		
2344:54 CAM-2	thirty oh five set.		
2344:55 CAM-3	thirty oh five set approach checklist complete.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
		2344:59 RDO-1	And Philly approach good day its UPS thirteen oh seven heavy with you passing one five five for one one thousand with Charlie.
		2345:19 APR	UPS thirteen oh seven heavy Philly runway two seven right altimeter three zero zero four.
		2345:25 RDO-1	thirty oh four two seven right UPS thirteen oh seven heavy.
		2346:29 APR	UPS thirteen oh seven heavy fly heading of zero five zero and descend and maintain six thousand.
		2346:33 RDO-1	zero five zero down six thousand UPS thirteen oh seven heavy.
2347:02 CAM-1	can you still smell it in the back there @?		
2347:06 CAM-3	yeah its uh *** smells like it was more to the back there.		
2347:12 CAM-?	**.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
2347:13 CAM-?	**.		
2347:14 CAM-1	smell like it more (strong) back there.		
2347:18 CAM-2	smells like cardboard burning doesn't it? you didn't see smoke though something like that?		
2347:29 CAM	[sound similar to cockpit door operating]		
2347:58 CAM	[sound similar to cockpit door operating]		
2347:59 CAM-3	it is definitely stronger in the back.		
2348:01 CAM-1	is that right?		
2348:02 CAM-3	yeah it is definitely stronger in the back.		
2348:04 CAM-1	huh.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2348:07 CAM-3	well does not appear to be any smoke or haze.		
2348:10 CAM-1	what's that?		
2348:10 CAM-3	I just shined my light back there I can't see any haze or anything.		
2348:14 CAM-1	no *.		
2348:21 CAM-1	did you did you try all the bleeds?		
2348:23 CAM-3	well I tried the second one off now maybe another one off.		
2348:27 CAM-1	okay.		
		2348:27 APR	UPS thirteen oh seven heavy fly heading zero six zero descend and maintain four thousand.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
		2348:31 RDO-1	zero six zero down to four thousand UPS thirteen oh seven heavy.
2348:41 CAM-2	four thousand *.		
		2348:52 RDO	[sound of beeps similar to IPDP Morse code identifier for I-L-S two seven right approach]
2352:30 CAM-1	does it seem to get any better with the packs smoke uh checklist?		
2352:35 CAM-2	flaps ten please.		
2352:38 CAM	[sound of click and beep similar to configuration horn]		
2352:41 CAM-3	pack smoke warning.		
2352:42 CAM-1	yeah that what I am doing under the pack smoke.		
2352:46 CAM-1	** fumes evacuation.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2352:47 CAM-3	** smoke yeah? no smoke detectors.		
2352:52 CAM-1	yeah yeah no smoke detectors going off.		
2352:54 CAM-3	**.		
2352:57 CAM-?	fumes evacuation because the packs ** the packs ** off **.		
2353:05 CAM-?	***.		
2353:07 CAM-?	***.		
2353:09 CAM-?	***.		
2353:19 CAM-2	flaps twenty five.		
2353:21 CAM	[sound of three clicks, similar to flap handle movement]		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
		2353:27 RDO	[sound of beeps similar to IPDP Morse code identifier for I-L-S two seven right approach]
2353:52 CAM	[sound of tone similar to altitude alert]		
2353:56 CAM-1	five for four.		
		2354:07 APR	UPS thirteen oh seven heavy turn left to zero one zero descend and maintain two thousand one hundred.
		2354:12 RDO-1	zero one zero down to two point one UPS thirteen oh seven heavy.
2354:20 CAM-2	two thousand one hundred.		
2354:42 CAM-3	okay we got cargo smoke.		
2354:45 CAM-1	you got cargo smoke?		
2354:47 CAM-3	**.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2354:50 CAM-1	let's do that checklist if you got time.		
2354:52 CAM-2	all right I am turning into the airport then.		
2354:57 CAM	[sound of tone similar to altitude alert]		
		2354:59 RDO-1	and ah UPS thirteen oh seven heavy has the field in sight.
		2355:01 APR	UPS thirteen zero seven heavy cleared for the visual approach runway two seven right contact the tower one eighteen five.
		2355:06 RDO-1	eighteen five seeya.
		2355:11 RDO-1	tower good day it is UPS thirteen oh seven heavy with you visual for two seven right.
		2355:15 TWR	thirteen oh seven heavy two seven right wind two six zero at six cleared to land.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
		2355:19 RDO-1	cleared to land and uh listen we just got a cargo smoke indicator come on can we have the equipment meet us?
		2355:27 TWR	okay I'll do that for you. cargo smoke indicator. [sound of ARFF alarm in background] uh uh just souls on board amount of fuel sir.
		2355:34 RDO-1	uh three souls uh two hours of fuel.
		2355:37 TWR	two hours of fuel roger that sir uh we are bringing them out now.
		2355:40 RDO-1	thanks.
2355:41 CAM	[sound similar to autopilot disconnect]		
2355:45 O2-2	gear down.		
2355:46 CAM-1	gear.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
2355:48 CAM	[sound similar to landing gear operation]		
2355:48 O2-2	landing checklist.		
2355:57 O2-3	okay its showing that we have a lower aft cargo fire section C.		
2355:57 CAM	[sound similar to altitude alerter]		
2355:58 CAM-1	oxygen masks on if you don't have 'em and uh run through that checklist @ by yourself okay?		
2356:03 O2-3	okay lower and uh or main cargo fire. oxygen masks on a hundred percent.		
		2356:12 TWR	UPS thirteen oh seven heavy is cleared to land runway two seven left the wind is uh two six zero at six.
		2356:18 RO2-1	cleared to land two seven left UPS thirteen oh seven.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2356:22 O2-3	okay I got.		
		2356:22 TWR	I am sorry last call on ground say again.
2356:24 O2-3	I got packs one off one on min flow. recirc fan is off. off. oxygen air diffuser valve open...		
		2356:35 TWR	and uh when you get a chance I know you are busy thirteen oh seven heavy can you give me fuel in pounds please?
		2356:44 RO2-1	twenty one thousand seven hundred.
		2356:46 TWR	thank you.
2356:48 O2-2	flaps thirty five.		
2356:50 O2-3	okay main cargo air shutoff valve is closed I gotta go in the back and do that.		
2356:56 CAM	[sound similar to cockpit door operating]		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2356:57 O2-2	smelling pretty good now.		
2356:58 O2-1	yeah.		
2357:02 O2-2	flaps full.		
2357:04 CAM	[sound similar to cockpit door operating]		
2357:05 O2-2	prepare to get that uh prepare to get that uh paperwork.		
2357:09 O2-3	yeah were going to have to do an evacuation 'kay. tell them we are going to have to do an evacuation when we get down.		
2357:19 O2-3	ok I got that valve shut off back there. there is smoke. radio pack blower switch off.		
2357:19 O2-2	I got it **.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2357:33 O2-3	cabin differential pressure maintain at point five P-S-I.		
2357:39 O2-3	we are almost on the ground.		
2357:44 O2-3	land as soon as possible.		
2357:47 O2-2	landing checklist when you get a chance.		
2357:51 O2-2	cleared to land?		
2357:57 O2-3	landing checklist.		
2357:59 O2-1	five hundred feet on speed sink is eight.		
2357:59 O2-3	flight instruments and radios.		
2358:03 CAM	glideslope. [GPWS voice]		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2358:04 CAM	five hundred. [GPWS voice]		
2358:06 O2-3	ignition. gear. anti-skid.		
		2358:08 TWR	and thirteen oh seven heavy just confirmed you are lined up for the left side it appears you are lined up for the right.
		2358:13 RO2-1	I'm sorry I thought we were cleared for the right uh are we cleared to land on the right?
		2358:16 TWR	uh you are cleared to land on the right we will just tell fire.
		2358:20 RO2-1	okay.
2358:23 CAM	glideslope glideslope glideslope. [GPWS voice]		
		2358:27 TWR	uh Foxtrot nine tower just be advised the aircraft is going to landing twenty seven right short final twenty seven right if you are on tower.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2358:40 CAM	glideslope. [GPWS voice]		
2358:46 O2-3	landing checks complete.		
2358:50 CAM	one hundred. [GPWS voice]		
		2358:51 A10	Philadelphia tower airport ten.
		2358:52 TWR	airport ten if you can just let the uh fire departments know we cannot reach them on the frequencies. the aircraft is landing twenty seven right.
2358:54 CAM	fifty. [GPWS voice]		
2358:55 CAM	thirty. [GPWS voice]		
2358:56 CAM	twenty. [GPWS voice]		
2358:57 CAM	ten. [GPWS voice]		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2359:00 CAM	[sound similar to spoiler handle movement]		
		2359:00 TWR	he is rolling out flaring as we speak.
		2359:01 A10	airport ten copies.
2359:02 O2-3	okay we got smoke in the cockpit now.		
2359:05 CAM	[sound similar to reverser deployment and engine acceleration]		
2359:11 O2-1	eighty.		
2359:13 O2-3	tell 'em we have smoke in the cockpit we are evacuating.		
2359:14 O2-1	seventy.		
2359:18 CAM-2	you have the aircraft.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
2359:21 CAM	[sound similar to window(s) being operated]		
2359:25 CAM-2	okay emergency evacuation.		
2359:26 CAM-1	evacuation checklist.		
		2359:27 ARFF	Philadelphia tower can we show two seven right closed and allow ARFF vehicles to the runway?
2359:29 CAM	[sound similar to coughing]		
2359:30 CAM-1	parking brake set.		
		2359:32 TWR	ah two zero nine proceed onto runway two seven right.
2359:33 CAM-2	fuel shut off levers off.		
2359:35 CAM-1	battery switch battery.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	**CONTENT**	**TIME and SOURCE**	**CONTENT**
		2359:38 RDO-2	UPS thirteen oh seven evacuating the aircraft.
2359:40 CAM-?	* right to be closed.		
		2359:41 TWR	two seven right is closed and the aircrew is evacuating the aircraft.
2359:41 CAM-2	fire handles full forward.		
2359:45 End of transcript			

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