Crash During a Nighttime Nonprecision Instrument Approach to Landing
UPS Flight 1354
Airbus A300-600, N155UP
Birmingham, Alabama
August 14, 2013

Accident Report

NTSB/AAR-14/02
PB2014-107898

National Transportation Safety Board

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PB2014-107898
Notation 8533A
Adopted September 9, 2014

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

National Transportation Safety Board. 2014. ***Crash During a Nighttime Nonprecision Instrument Approach to Landing, UPS Flight 1354, Airbus A300-600, N155UP, Birmingham, Alabama, August 14, 2013*****. NTSB/AAR-14/02. Washington, DC.**

Abstract: This report discusses the August 14, 2013, accident involving an Airbus A300-600, N155UP, operating as UPS flight 1354, which crashed short of runway 18 during a localizer nonprecision approach to runway 18 at Birmingham-Shuttlesworth International Airport, Birmingham, Alabama. The captain and first officer were fatally injured, and the airplane was destroyed. Safety issues relate to the need for clear communications to flight crews about weather conditions, between dispatchers and flight crews, and between flight crewmembers; off-duty time management, fatigue awareness, and counseling; use of the continuous descent final approach technique; standardized guidance; and altitude alerts. Safety recommendations are addressed to the Federal Aviation Administration, UPS, Airbus, and the Independent Pilots Association.

For more detailed background information on this report, visit http://www.ntsb.gov/investigations/dms.html and search for NTSB accident ID DCA13MA133. Recent publications are available in their entirety on the Internet at http://www.ntsb.gov. Other information about available publications also may be obtained from the website or by contacting:

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Abbreviations

AC	advisory circular
ACARS	aircraft communication addressing and reporting system
AFE	above field elevation
agl	above ground level
AOM	aircraft operating manual
ARFF	aircraft rescue and firefighting
ASOS	automated surface observing system
ASRS	aviation safety reporting system
ATC	air traffic control
ATCT	air traffic control tower
ATIS	automatic terminal information service
BHM	Birmingham-Shuttlesworth International Airport
CDFA	continuous descent final approach
CDT	central daylight time
CDU	control display unit
CFIT	controlled flight into terrain
CFR	*Code of Federal Regulations*
CRM	crew resource management
CVR	cockpit voice recorder
DRM	dispatcher resource management
EDT	eastern daylight time
EGPWS	enhanced ground proximity warning system
ETVS	enhanced terminal voice switch

FAA	Federal Aviation Administration
FAF	final approach fix
FCOM	flight crew operating manual
FDP	flight duty period
FDR	flight data recorder
FMC	flight management computer
FOM	flight operations manual
FOTM	flight operations training manual
fpm	feet per minute
FRMP	fatigue risk management plan
FWC	flight warning computer
HAT	height above touchdown
HOU	William P. Hobby Airport
ICAO	International Civil Aviation Organization
ILS	instrument landing system
IMC	instrument meteorological conditions
IPA	Independent Pilots Association
MEL	minimum equipment list
METAR	meteorological aerodrome report
mi	mile
min	minute
msl	mean sea level
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
ND	navigation display

nm	nautical mile
NOTAM	notice to airmen
NTSB	National Transportation Safety Board
NWS	National Weather Service
OpSpec	operations specification
PAPI	precision approach path indicator
PED	portable electronic device
PF	pilot flying
PFD	primary flight display
PIA	General Downing-Peoria International Airport
PM	pilot monitoring
POI	principal operations inspector
PTG	pilot training guide
RFD	Chicago/Rockford International Airport
RNAV	nonprecision en route area navigation
RVR	runway visual range
SAFO	safety alert for operators
SAT	San Antonio International Airport
SDF	Louisville International Airport-Standiford Field
SNPRM	supplemental notice of proposed rulemaking
SOP	standard operating procedure
SPECI	special weather observation
TAWS	terrain awareness and warning system
TRACON	terminal radar approach control
TSO	technical standard order

VDI	vertical deviation indicator
VGSI	visual glideslope indicator
VMC	visual meteorological conditions
VNAV	vertical navigation

Executive Summary

On August 14, 2013, about 0447 central daylight time (CDT), UPS flight 1354, an Airbus A300-600, N155UP, crashed short of runway 18 during a localizer nonprecision approach to runway 18 at Birmingham-Shuttlesworth International Airport (BHM), Birmingham, Alabama. The captain and first officer were fatally injured, and the airplane was destroyed by impact forces and postcrash fire. The scheduled cargo flight was operating under the provisions of 14 *Code of Federal Regulations* Part 121 on an instrument flight rules flight plan, and dark night visual flight rules conditions prevailed at the airport; variable instrument meteorological conditions with a variable ceiling were present north of the airport on the approach course at the time of the accident. The flight originated from Louisville International Airport-Standiford Field, Louisville, Kentucky, about 0503 eastern daylight time.

A notice to airmen in effect at the time of the accident indicated that runway 06/24, the longest runway available at the airport and the one with a precision approach, would be closed from 0400 to 0500 CDT. Because the flight's scheduled arrival time was 0451, only the shorter runway 18 with a nonprecision approach was available to the crew. Forecasted weather at BHM indicated that the low ceilings upon arrival required an alternate airport, but the dispatcher did not discuss the low ceilings, the single-approach option to the airport, or the reopening of runway 06/24 about 0500 with the flight crew. Further, during the flight, information about variable ceilings at the airport was not provided to the flight crew.

The captain was the pilot flying, and the first officer was the pilot monitoring. Before descent, while on the direct-to-KBHM leg of the flight, the captain briefed the localizer runway 18 nonprecision profile approach, and the first officer entered the approach into the airplane's flight management computer (FMC). The intended method of descent (a "profile approach") used a glidepath generated by the FMC to provide vertical path guidance to the crew during the descent from the final approach fix (FAF) to the decision altitude, as opposed to the step-down method ("dive and drive") that did not provide vertical guidance and required the crew to refer to the altimeter to ensure that the airplane remained above the minimum crossing altitude at each of the approach fixes. When flown as a profile approach, the localizer approach to runway 18 had a decision altitude of 1,200 ft mean sea level (msl), which required the pilots to decide at that point to continue descending to the runway if the runway was in sight or execute a missed approach.

As the airplane neared the FAF, the air traffic controller cleared the flight for the localizer 18 approach. However, although the flight plan for the approach had already been entered in the FMC, the captain did not request and the first officer did not verify that the flight plan reflected only the approach fixes; therefore, the direct-to-KBHM[1] leg that had been set up during the flight from Louisville remained in the FMC. This caused a flight plan discontinuity message to remain in the FMC, which rendered the glideslope generated for the profile approach

[1] In this report, BHM refers to the airport and KBHM refers to the waypoint.

meaningless.[2] The controller then cleared the pilots to land on runway 18, and the first officer performed the Before Landing checklist. The airplane approached the FAF at an altitude of 2,500 ft msl, which was 200 ft higher than the published minimum crossing altitude of 2,300 ft.

Had the FMC been properly sequenced and the profile approach selected, the autopilot would have engaged the profile approach and the airplane would have begun a descent on the glidepath to the runway. However, this did not occur. Neither pilot recognized the flight plan was not verified. Further, because of the meaningless FMC glidepath, the vertical deviation indicator (VDI), which is the primary source of vertical path correction information, would have been pegged at the top of its scale (a full-scale deflection), indicating the airplane was more than 200 ft below the (meaningless) glidepath. However, neither pilot recognized the meaningless information even though they knew they were above, not below, the glideslope at the FAF. When the autopilot did not engage in profile mode, the captain changed the autopilot mode to the vertical speed mode, yet he did not brief the first officer of the autopilot mode change. Further, by selecting the vertical speed mode, the approach essentially became a "dive and drive" approach. In a profile approach, a go-around is required upon arrival at the decision altitude (1,200 ft) if the runway is not in sight; in a "dive-and-drive" approach, the pilot descends the airplane to the minimum descent altitude (also 1,200 ft in the case of the localizer approach to runway 18 at BHM) and levels off. Descent below the minimum descent altitude is not permitted until the runway is in sight and the aircraft can make a normal descent to the runway. A go-around is not required for a "dive and drive" approach until the airplane reaches the missed approach point at the minimum descent altitude and the runway is not in sight. Because the airplane was descending in vertical speed mode without valid vertical path guidance from the VDI, it became even more critical for the flight crew to monitor their altitude and level off at the minimum descent altitude.

About 7 seconds after the first officer completed the Before Landing checklist, the first officer noted that the captain had switched the autopilot to vertical speed mode; shortly thereafter, the captain increased the vertical descent rate to 1,500 feet per minute (fpm). The first officer made the required 1,000-ft above-airport-elevation callout, and the captain noted that the decision altitude was 1,200 ft msl but maintained the 1,500 fpm descent rate. Once the airplane descended below 1,000 ft at a descent rate greater than 1,000 fpm, the approach would have violated the stabilized approach criteria defined in the UPS flight operations manual and would have required a go-around. As the airplane descended to the minimum descent altitude, the first officer did not make the required callouts regarding approaching and reaching the minimum descent altitude, and the captain did not arrest the descent at the minimum descent altitude.

The airplane continued to descend, and at 1,000 ft msl (about 250 ft above ground level), an enhanced ground proximity warning system (EGPWS)[3] "sink rate" caution alert was triggered. The captain began to adjust the vertical speed in accordance with UPS's trained procedure, and he reported the runway in sight about 3.5 seconds after the "sink rate" caution

[2] Although the display was correct based on the information the flight crew input to the system, the information output was meaningless for the approach.

[3] The airplane was equipped with a Honeywell EGPWS, which is a type of terrain awareness and warning system.

alert. The airplane continued to descend at a rate of about 1,000 fpm. The first officer then confirmed that she also had the runway in sight. About 2 seconds after reporting the runway in sight, the captain further reduced the commanded vertical speed, but the airplane was still descending rapidly on a trajectory that was about 1 nautical mile short of the runway. Neither pilot appeared to be aware of the airplane's altitude after the first officer's 1,000-ft callout. The cockpit voice recorder then recorded the sound of the airplane contacting trees followed by an EGPWS "too low terrain" caution alert.

The safety issues discussed in this report relate to the need for the following:

- **Clear communications.** This investigation identified several areas in which communication was lacking both before and during the flight, which played a role in the development of the accident scenario.
  - **Dispatcher and flight crew.** Before departure, the dispatcher and the flight crew did not verbally communicate with each other even though dispatchers and pilots share equal responsibility for the safety of the flight. In this case, the dispatcher was aware of a runway closure, approach limitations, and weather that warranted discussion between the dispatcher and the pilots. However, neither the dispatcher nor the flight crew contacted each other to discuss these issues.
  - **Between flight crewmembers.** During the flight, the captain did not rebrief the approach after he switched the autopilot from the profile to the vertical speed mode. Therefore, the first officer was initially unaware of the change and had to seek out information on the type of approach being flown. The purpose of briefing any change in the approach is to ensure that crewmembers have a shared understanding of the approach to be flown. Because the captain did not communicate his intentions, it was not possible for the first officer to have a shared understanding of the approach, and her situational awareness was degraded.
  - **Weather.** Lastly, the relevant weather was not provided to the crew: the meteorological aerodrome reports (METARs) provided to the crew did not contain information about variable ceilings at BHM because the weather dissemination system used by UPS automatically removed the "remarks" section of METAR reports, where this information was contained. Further, the air traffic controllers did not include the "remarks" information in the automatic terminal information service broadcast. The lack of communication about the variable ceilings may have played a role in the flight crewmembers' expectation that they would see the airport immediately after passing 1,000 ft above the ground, when in fact they only saw the runway about 5 seconds before impacting the trees. If they would have had access to the METAR remarks, the flight crew may have been more aware of the possibility of lower ceilings upon arrival at BHM.
- **Off-duty time management, fatigue awareness, and counseling.** Review of the first officer's use of her off-duty time indicated that she was likely experiencing fatigue, primarily due to improper off-duty time management. Even though the first officer was aware that she was very tired, she did not call in and report that she was fatigued, contrary to the UPS fatigue policy. Further, fatigue and fitness for duty are

not required preflight briefing items; if they were, the first officer would have had the opportunity to identify the risks associated with fatigue and mitigate those risks before the airplane departed. Further, fatigue counseling for pilots would help to increase awareness and understanding about fatigue and the circumstances surrounding fatigue calls and better equip operators to provide guidance for managing fatigue while fostering an environment wherein all pilots call in fatigued when necessary.

- **Use of continuous descent final approach technique.** Nonprecision approaches do not provide any ground-based vertical flightpath guidance to flight crews and therefore can be more challenging to fly than precision approaches. These factors may contribute to the higher occurrence of unstabilized nonprecision approaches compared to precision approaches. Federal Aviation Administration (FAA) Advisory Circular 120-108, "Continuous Descent Final Approach [CDFA]," outlines a nonprecision approach technique that uses a stable, continuous path to the runway. Flight crews should be able to easily set up a CDFA approach using available airplane technology that generates vertical flightpath guidance internally when ground-based vertical navigation equipment is not available. The use of CDFA techniques while flying nonprecision approaches can provide an additional means of standardization for flight crews when they are conducting nonprecision approaches and reduce the risk of an unstabilized approach.

- **Standardized guidance.** UPS flight crews received guidance from several UPS publications, including the aircraft operating manual, the flight operations manual, and the pilot training guide (PTG). However, the PTG is not a required manual and is only an internal UPS reference manual. The National Transportation Safety Board (NTSB) found a lack of standardization among the documents, and some critical procedures contained within the PTG were not found in the other manuals, such as EGPWS alert responses; planned approach procedures, such as the CDFA technique; and procedures critical to approach setup and sequencing. It is critical that such procedures be contained in an FAA-accepted or -approved document that is onboard the airplane so that they will be subject to FAA review and so that pilots can be both trained and tested on the procedures.

- **Altitude alerts.** The airplane was equipped with an EGPWS that could, if activated, provide a 500-ft alert. This feature is required by terrain awareness and warning system Technical Standard Order C151A, but there is no FAA requirement for operators to activate the feature. Airbus operators typically use the flight warning computer 400-ft alert in lieu of the EGPWS 500-ft alert, but UPS had not activated either alert on its A300 fleet. Additionally, the flight warning computer was equipped with an automated aural "minimums" alert, but UPS had not activated this alert either. Although it cannot be known how the accident crew would have responded to these alerts had they been activated, in general the alerts can provide a beneficial reminder to pilots about the airplane's altitude above terrain.

The National Transportation Safety Board determines that the probable cause of this accident was the flight crew's continuation of an unstabilized approach and their failure to monitor the aircraft's altitude during the approach, which led to an inadvertent descent below the minimum approach altitude and subsequently into terrain. Contributing to the accident were

(1) the flight crew's failure to properly configure and verify the flight management computer for the profile approach; (2) the captain's failure to communicate his intentions to the first officer once it became apparent the vertical profile was not captured; (3) the flight crew's expectation that they would break out of the clouds at 1,000 feet above ground level due to incomplete weather information; (4) the first officer's failure to make the required minimums callouts; (5) the captain's performance deficiencies likely due to factors including, but not limited to, fatigue, distraction, or confusion, consistent with performance deficiencies exhibited during training; and (6) the first officer's fatigue due to acute sleep loss resulting from her ineffective off-duty time management and circadian factors.

As a result of this investigation, the NTSB makes safety recommendations to the FAA, UPS, Airbus, and the Independent Pilots Association.

1. Factual Information

1.1 History of Flight

On August 14, 2013, about 0447 central daylight time (CDT),[1] UPS flight 1354, an Airbus A300-600, N155UP, crashed short of runway 18 during a localizer nonprecision approach to runway 18 at Birmingham-Shuttlesworth International Airport (BHM), Birmingham, Alabama. The captain and first officer were fatally injured, and the airplane was destroyed by impact forces and postcrash fire. 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, and dark night visual flight rules conditions prevailed at the airport; variable instrument meteorological conditions (IMC) with a variable ceiling were present north of the airport on the approach course at the time of the accident. The flight originated from Louisville International Airport-Standiford Field (SDF), Louisville, Kentucky, about 0503 eastern daylight time (EDT) (see figure 1).[2]

A notice to airmen (NOTAM) in effect at the time of the accident noted that runway 06/24, which is 11,998 ft long, would be closed from 0400 to 0500 due to runway lighting system maintenance. Because UPS flight 1354's scheduled arrival time was 0451, only runway 18, which is 7,099 ft long, would have been available. Accordingly, the UPS dispatcher planned for the flight to land on runway 18. Because the Jeppesen approach chart noted (erroneously) in the minimums section that the nonprecision localizer[3] approach to runway 18 was not authorized at night,[4] the dispatcher thought that the nonprecision area navigation (RNAV)[5] GPS approach would be required. The pilots' flight briefing package contained the NOTAM for the runway 06/24 closure and landing performance data for runway 18.

[1] Unless otherwise noted, all times in this report are CDT based on a 24-hour clock.

[2] The National Transportation Safety Board (NTSB) public docket for this accident investigation, NTSB case number DCA13MA133, is available online at www.ntsb.gov .

[3] Instrument approach procedures fall into two categories: precision and nonprecision. Whereas precision approaches use ground-based navigation aids to provide lateral and vertical guidance to the desired touchdown point on the runway, nonprecision approaches use ground-based navigation aids (or satellite-based GPS) to provide only lateral guidance to the runway. Vertical guidance is provided by the designation of minimum altitudes at specified points, or fixes, that are progressively lower the closer the fixes are to the runway threshold. A localizer is an electromagnetically defined course line usually along the extended centerline of a runway that provides lateral course guidance.

[4] Jeppesen indicated that at the time of the accident, this note regarding the localizer approach was a publishing error and was corrected after the accident.

[5] According to Federal Aviation Administration (FAA) Advisory Circular 90-100A, "U.S. Terminal and En Route Area Navigation (RNAV) Operations," RNAV is "a method of navigation [that] permits aircraft operation on any desired flight path within the coverage of station-referenced navigation aids or within the limits of the capability of self-contained aids, or a combination of these." Some RNAV (GPS) approaches use satellite signals to provide vertical guidance to the runway, just as precision approaches use ground-based signals to provide this guidance. However, these RNAV approaches are still considered nonprecision approaches.

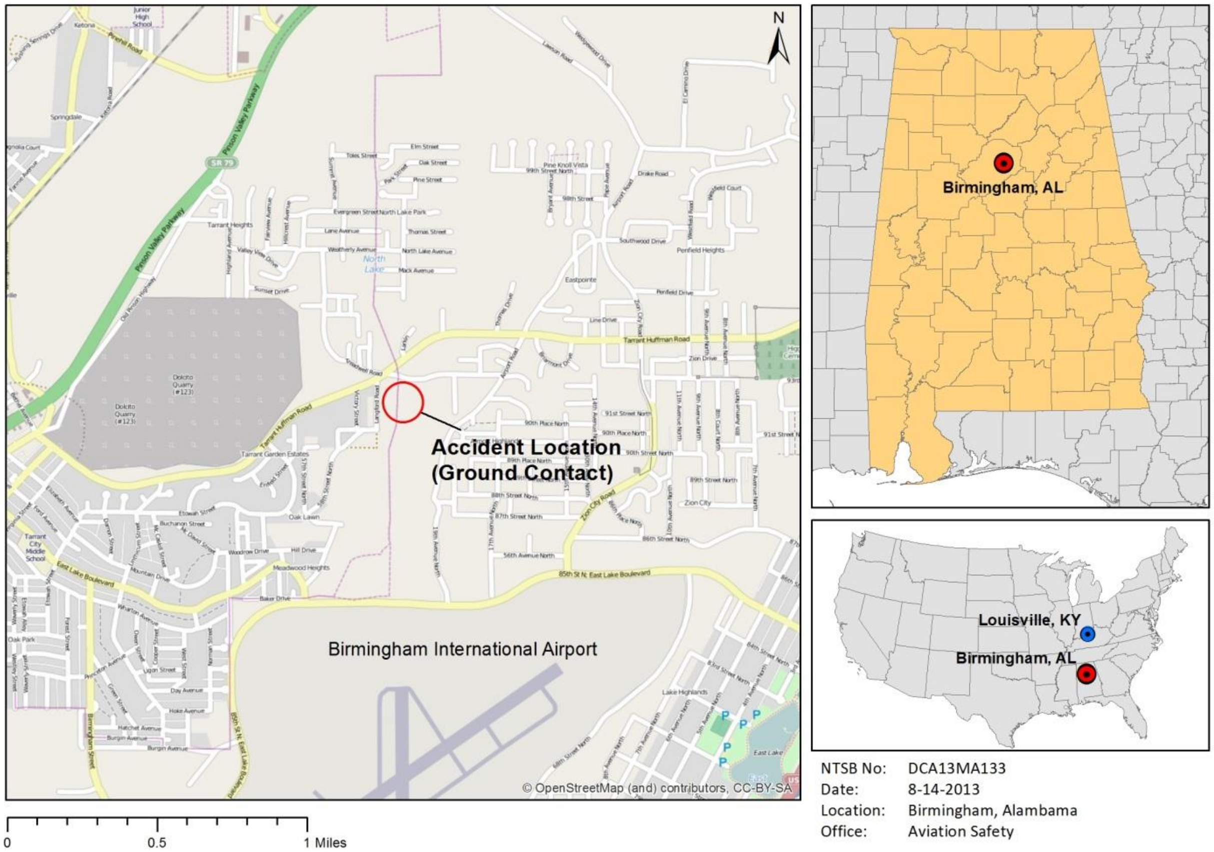

Figure 1. Maps showing (1) Birmingham, Alabama, and Louisville, Kentucky, on a US map; (2) Birmingham's location within the State of Alabama; and (3) the crash site on the north side of BHM.

Although the dispatcher thought that the only approach available to the flight crew was the RNAV GPS approach to runway 18, he did not inform the pilots, and nothing in the paperwork advised the flight crew that this was the only approach available to runway 18. In addition, the forecast ceiling for the approach to runway 18 was predicted to be below the minimum descent altitude for the RNAV GPS approach at the time of arrival.[6] As a result, the flight may have had to divert to its alternate of Hartsfield-Jackson Atlanta International Airport, Atlanta, Georgia, or hold until the longer runway opened. However, the dispatcher did not discuss this possibility or remind the flight crew that runway 06/24 would reopen about 0500.

The flight departed SDF about 0403. Cockpit voice recorder (CVR) and flight data recorder (FDR) data indicate that the en route portion of the flight from SDF to BHM appeared

[6] The minimum descent altitude for the RNAV GPS 18 approach at BHM is 1,200 ft mean sea level, and the required visibility is 1 1/2 miles.

routine. CVR and dispatch information indicated that the captain was the pilot flying (PF) and the first officer was the pilot monitoring (PM).

At 0421:28, the CVR recorded the first officer stating, "they're sayin' six and two-four is closed. They're doin' the localizer to one eight," after the flight crew listened to BHM automatic terminal information service (ATIS) Papa,[7] which included the 06/24 runway closure. The captain responded, "localizer (to) one eight, it figures." Between 0423 and 0430, the captain briefed the localizer runway 18 approach using the UPS Profile Briefing Guide from the UPS Aircraft Operating Manual (AOM). The briefing items included determining that the decision altitude was 1,200 ft,[8] verifying the vertical navigation (VNAV)/profile path[9] on the approach chart, reading the profile path ball note[10] on the approach chart, loading the approach in the flight management computer (FMC),[11] selecting the profile button on the mode control panel, and verifying that profile was armed.[12] The captain then continued to review the localizer 18 approach chart including the following items: 1,200-ft decision altitude with 560 ft on the radio altimeter, touchdown zone elevation, minimum sector altitude, charted missed approach, aircraft configuration for the missed approach, runway environment and lighting, expected turnoff taxiway, and low brakes. At no time did the captain or first officer mention that the localizer approach was not available, as indicated on the Jeppesen chart.

At 0433:33, air traffic control (ATC) cleared the flight to descend to 11,000 ft mean sea level (msl), and the captain commented, "They're generous today. Usually they kind'a take you to fifteen and they hold you up high." At 0441:44, while flying level at 11,000 ft msl, the first officer contacted BHM approach control advising that they had ATIS information Papa and requesting a lower altitude. The BHM approach controller issued a descent clearance to 3,000 ft and said, "uhm...runway six is still closed. you want…the localizer one eight?" The flight crew accepted the localizer 18 approach (see figure 2).

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[7] ATIS is the continuous broadcast of recorded noncontrol information in selected high-activity terminal areas. At 0453, ATIS Papa reported, "Zero eight five three zulu observation. Sky condition ceiling one thousand broken seven thousand five hundred overcast. Temperature two three dew point two two altimeter two niner niner seven. Localizer runway one eight in use. Landing and departing runway one eight. Notice to Airmen runway six/two four closed. All departing aircraft contact tower one one niner point niner for clearance, taxi and takeoff. Advise controller on initial contact you have PAPA."

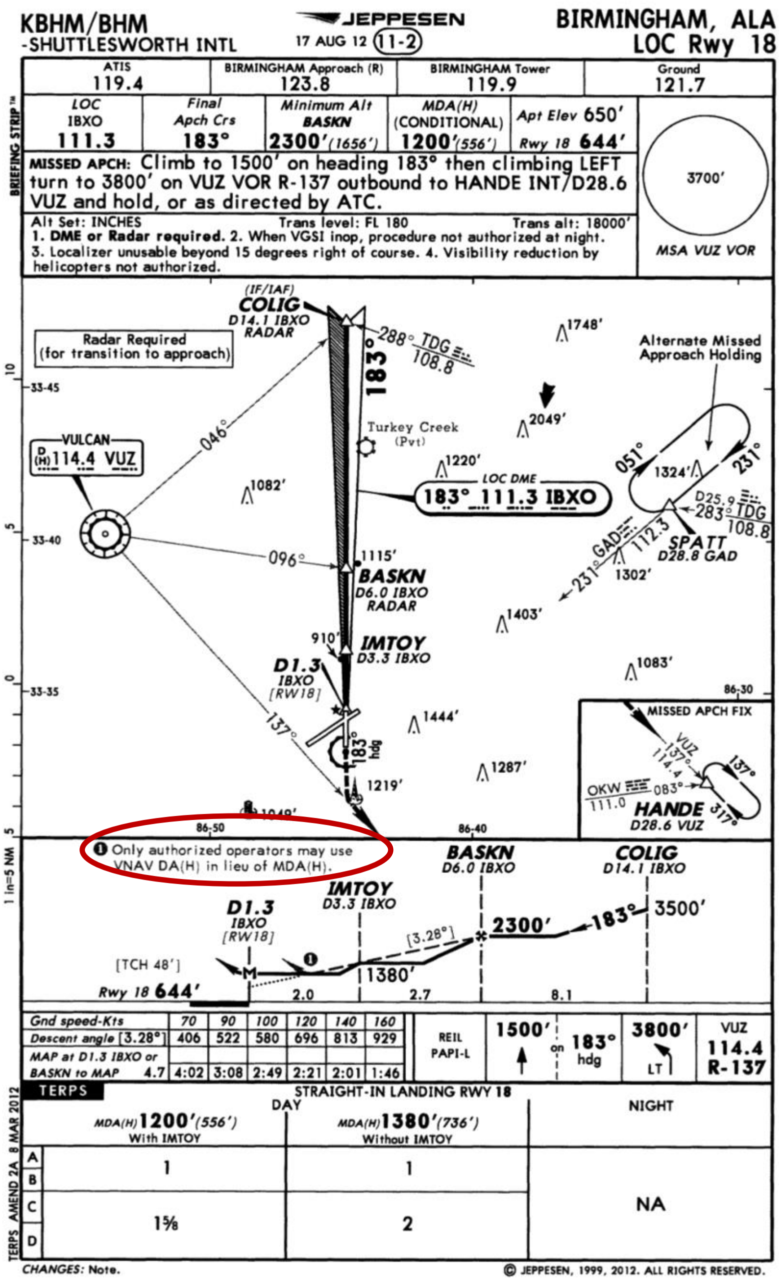
[8] On a precision approach, the decision altitude is the altitude at which a missed approach must be initiated if the required visual reference is not in sight. On a typical nonprecision approach that does not provide a VNAV vertical guidance, the airplane descends to the minimum descent altitude (see section 1.6.2.7).

[9] VNAV is a function of certain RNAV systems that presents computed vertical guidance to the pilot referenced to a specified vertical path. The computed vertical guidance is based on barometric altitude information and is typically computed as a geometric path between two waypoints or an angle based on a single waypoint. The A300 autopilot flight director system's profile mode is used to fly the VNAV path computed by the flight management computer while in final approach mode. Profile mode is authorized on the A300 to fly the VNAV path down to a barometric decision altitude or derived decision altitude as applicable, after final approach mode is activated by the flight crew. For the purposes of this report, "profile glidepath" and "VNAV path" are synonymous.

10 A "ball note" on a Jeppesen chart is a note on the chart that provides additional information (see figure 2).

[11] When setting up the FMC for the profile approach, the pilot verifies the glidepath angle that is used to construct the desired glidepath. The height of the glidepath at any given time is computed based on this angle and the airplane's distance from the runway threshold, as determined by the FMC. This FMC-computed distance is not simply the length along the ground of a straight line drawn from the airplane's current position over the ground to the threshold; rather, the distance is the sum of the length of all the navigation legs between the airplane's current position over the ground and the runway threshold, as entered in the FMC.

[12] The PM loaded the approach into the FMC and reviewed it for accuracy. The PF was to verify the approach accuracy during the approach briefing.



(Used by permission of Jeppesen Sanderson Inc. NOT TO BE USED FOR NAVIGATION.)

Figure 2. Instrument approach chart for the localizer approach for runway 18 at BHM at the time of the accident with the ball note circled in red.

The glidepath for the runway 18 localizer approach, indicated by the dashed line and 3.28° at the bottom of figure 2, is defined by the minimum crossing altitude at three approach fixes (COLIG, BASKN, and IMTOY) aligned north of the extended runway 18 centerline. The localizer approach to runway 18 had a minimum descent altitude of 1,200 ft msl. Because the crew was initially flying a profile approach, they were to descend to a decision altitude (also

1,200 feet), rather than the minimum descent altitude.[13] At the decision altitude, the pilot would make a decision to continue descending to the runway, if the runway was in sight, or execute a missed approach. For a step-down approach, the minimum descent altitude is the altitude the airplane cannot descend below until the required visual reference is obtained; if visual reference is not obtained, the pilot must conduct a go-around at the missed approach point.[14]

At 0442:05, the approach controller began to vector the flight for the approach and cleared the flight crew to "turn ten degrees right, join the localizer, maintain three thousand." During that time, the PM would normally configure the FMC by resequencing[15] the computer to reflect only the anticipated fixes to be flown on the approach. Resequencing is a common action by flight crews and is accomplished on all UPS approaches. Between the heading clearance at 0442:05 and 0443:53.5, when the localizer began to capture, the crew was engaged in a conversation about the lack of approach options to the runway and their perception that ATC had left them high on the approach.

At 0443:24, as the airplane descended through about 6,900 ft msl with the landing gear extended and the autopilot engaged, the approach controller cleared the flight for the approach stating, "maintain two thousand five hundred [msl] till established on localizer, cleared localizer one eight approach." However, because the flight crew did not verify the flight plan, the FMC was still on a direct course to KBHM[16] rather than on a course to the appropriate approach fix, which, at this point, would have been COLIG.

The airplane was 2.4 nautical miles (nm) from COLIG and 10.5 nm from the BASKN final approach fix (FAF) at this time (see figure 3, which shows the airplane's descent path). It was established on the localizer when it descended through 3,800 ft msl and was aligned laterally with the extended centerline of runway 18; the airplane maintained lateral alignment with the extended centerline for the remainder of the flight. When the airplane reached 2,500 ft msl about 4 nm from BASKN (about 9 nm from the runway), it leveled off, even though it was established on the localizer and could have descended to 2,300 ft, as shown in figure 3.

[13] The later change in approach type would have required a minimum descent altitude.

[14] For the localizer 18 approach to BHM flown as a step-down approach, the missed approach point was the approach end of runway 18, or 1.3 distance-measuring-equipment miles on the localizer.

[15] For the purposes of this report, "sequencing the flight plan" refers to clearing the route discontinuity and undesired waypoints so the FMC flight plan only reflects the anticipated waypoints to be flown for the approach.

[16] In this report, BHM refers to the airport and KBHM refers to the waypoint.

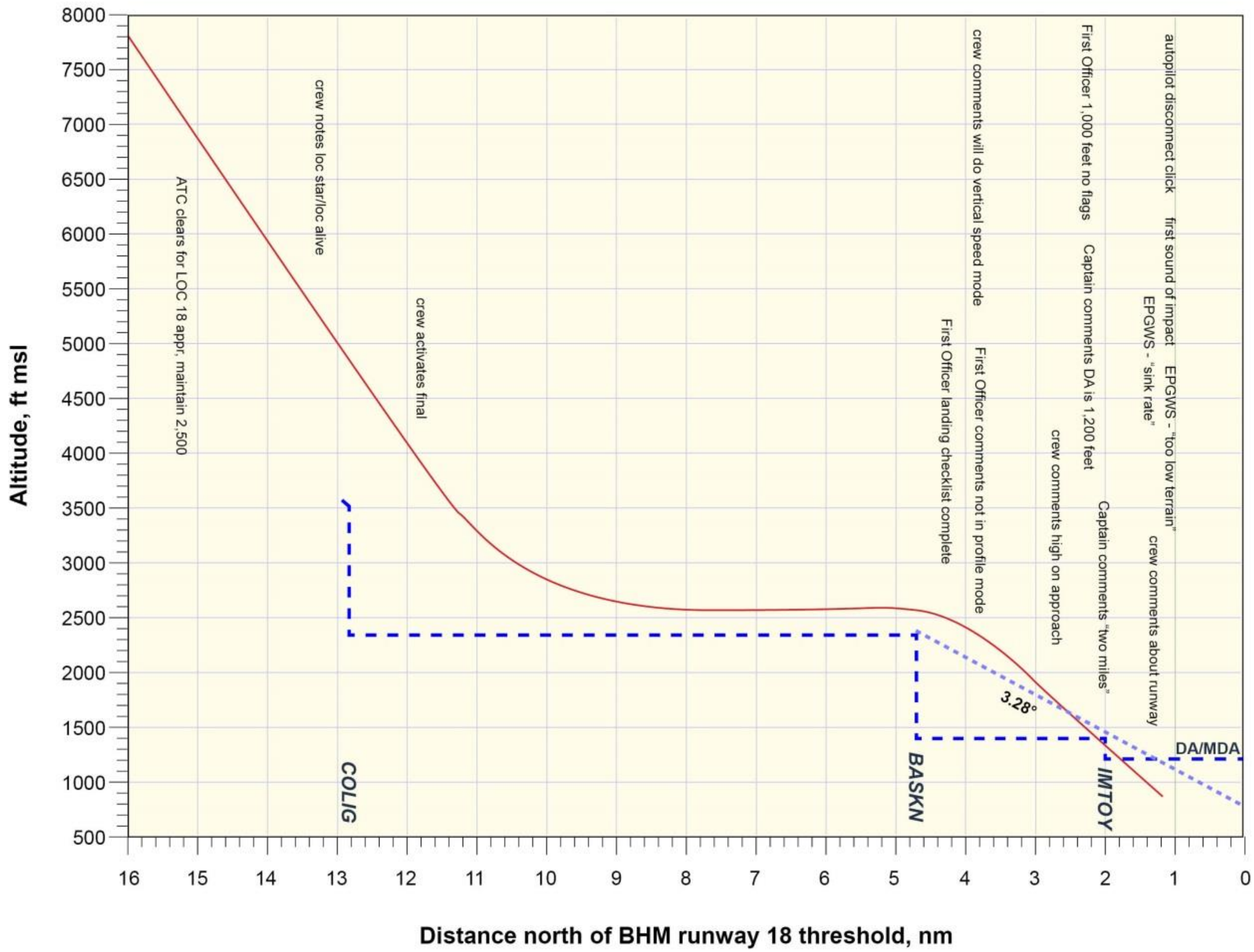


Figure 3. UPS flight 1354's actual descent and altitudes.

As the airplane neared the BASKN FAF, the controller cleared the pilots to land on runway 18, and the first officer performed the Before Landing checklist. The airplane approached BASKN at an altitude of 2,500 ft msl, which was 200 ft higher than the FAF's minimum crossing altitude and contrary to the UPS A300 Pilot Training Guide (PTG) recommendation that the airplane descend to the FAF crossing altitude before intercepting the profile path. Because the approach was still sequenced for a direct-to-KBHM course, the airplane continued flying toward BASKN at 2,500 ft and did not capture the desired profile glidepath. During this time, the captain changed the autopilot mode from the previously briefed profile approach to vertical speed mode,[20] initially setting the vertical descent rate to about 700 ft per minute (fpm), then increasing it to 1,000 fpm; however, he did not brief the first officer about the autopilot mode change.

At 0446:24.7, about 7 seconds after the first officer completed the Before Landing checklist, she noted the change to vertical speed mode. The captain responded, "Yeah I'm gonna do vertical speed. yeah he kept us high." At 0446:29.6, the first officer said, "kept ya high. could never get it over to profile (we didn't) do it like that." The captain then increased the vertical descent rate to 1,500 fpm, and the airplane continued to descend at that rate as it approached the IMTOY stepdown fix. At 0447:03, when the airplane was about 1,530 ft msl, the first officer stated, "there's a thousand ft [above airport elevation]…instruments cross checked no flags." The captain responded, "alright ah DA [decision altitude] is twelve ah hundred [msl]."[21]

At 0447:10.9, as the airplane passed the IMTOY stepdown fix at an altitude near the charted minimum crossing altitude of 1,380 ft msl, the captain stated "two miles." However, the airplane continued to descend at 1,500 fpm and passed through and continued below the desired glidepath. As the airplane approached and then descended through the minimum descent altitude of 1,200 ft msl, neither pilot made the required callouts regarding approaching and reaching the minimum descent altitude. At 0447:19.6 the first officer said, "it wouldn't happen to be actual [chuckle]."[22]

At an altitude of about 1,000 ft msl (about 250 ft above ground level [agl]), an enhanced ground proximity warning system (EGPWS)[23] "sink rate" caution alert was triggered.[24] About 1 second later, the captain began to reduce the selected vertical speed to about 600 fpm. The captain reported the runway in sight about 3.5 seconds after the "sink rate" caution alert, and the first officer then confirmed that she also had the runway in sight. About 2 seconds after reporting the runway in sight, the captain further reduced the selected vertical speed to 400 fpm. At 0447:31.5, the captain disconnected the autopilot, and a second later, the CVR recorded the sound of rustling, corresponding to the airplane's first contact with trees. The CVR then recorded

[20] Vertical speed mode maintains the pilot-selected vertical speed.

[21] Although the captain said, "DA," based on the change to the approach, the decision altitude would have changed to a minimum descent altitude.

[22] CVR transcript-related items in square brackets are editorial comments and a description of sounds other than words.

[23] The airplane was equipped with a Honeywell EGPWS, which is a type of terrain awareness and warning system.

[24] Review of recorded radar data indicated that the flight remained well above the current and predicted warning slopes within the BHM minimum safe altitude warning area, thus no minimum safe altitude warning alerts were generated.

an EGPWS "too low terrain" caution alert and several additional impact noises until the recording ended.

Postaccident examination revealed that the airplane struck several trees and ingested tree debris into both engines during its descent toward runway 18. Pieces of airplane wreckage associated with the initial impacts were found about 1 1/4 miles (mi) north of the runway threshold and consisted mostly of small fragments of left wing, engine nacelle, and engine inlet material. The airplane struck more trees, a power pole, and power lines before it impacted downsloping terrain in a large gulley north of the runway 18 threshold. The debris path continued to the bottom of the gulley and up the adjacent side. Figure 4 is an overhead photograph of the wreckage path.

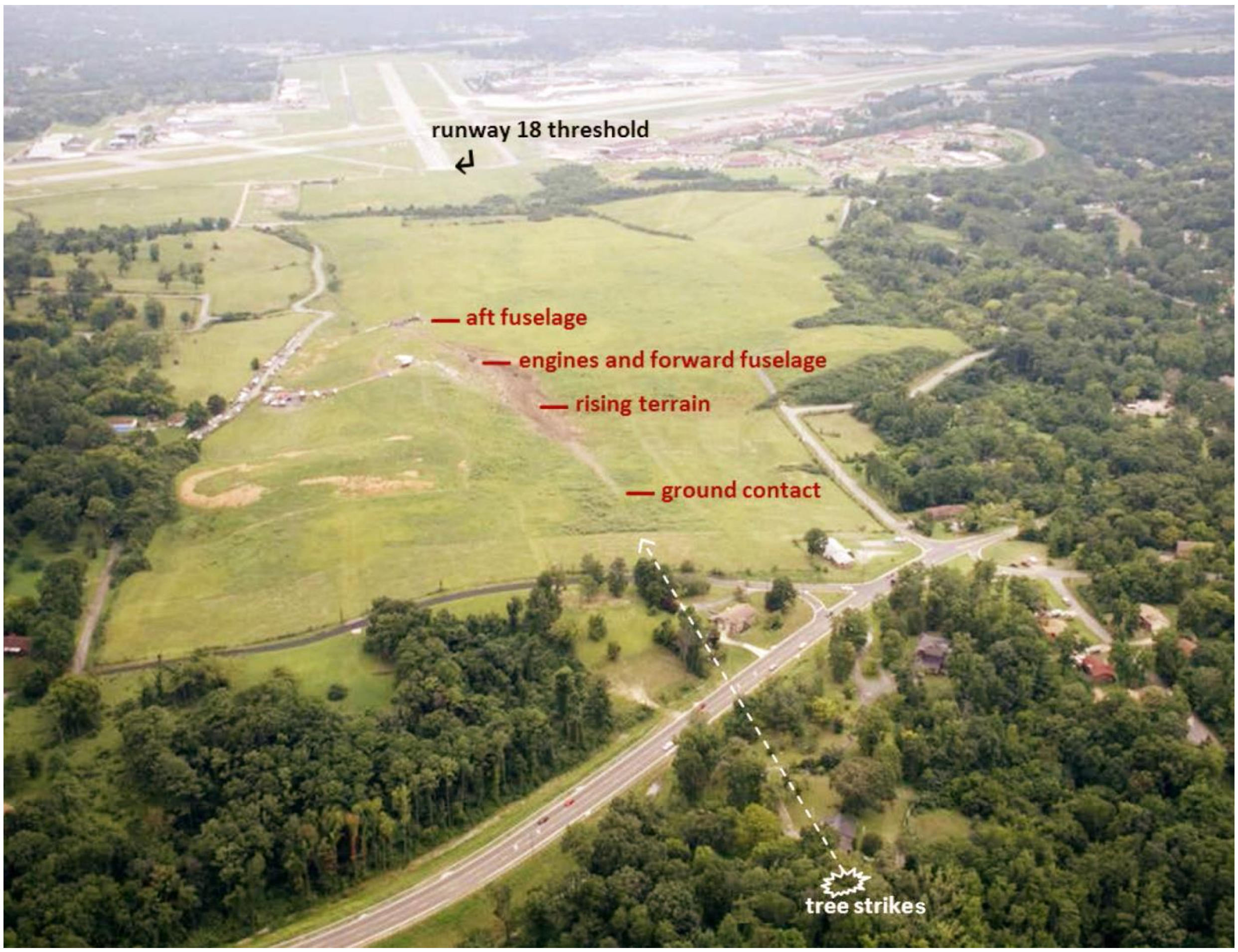


Figure 4. Overhead photograph of the wreckage path.

1.2 Injuries to Persons

Table 1. Injury chart.

Injuries	Flight Crew	Cabin Crew	Passengers	Other	Total
Fatal	2	0	0	0	2
Serious	0	0	0	0	0
Minor	0	0	0	0	0
None	0	0	0	0	0
Total	2	0	0	0	2

1.3 Damage to Aircraft

The airplane was destroyed by impact forces and postcrash fire. Images recorded by several surveillance video cameras based at the airport showed the fire associated with the airplane's ground impact and the presence of low clouds above the impact area (see figure 5). The forward fuselage was largely intact; however, the lower portion of the fuselage, especially under the cockpit, sustained severe impact damage. The left wing was highly fragmented. The right wing, aft fuselage, and tail sustained significant fire damage. For additional wreckage information, see section 1.12.

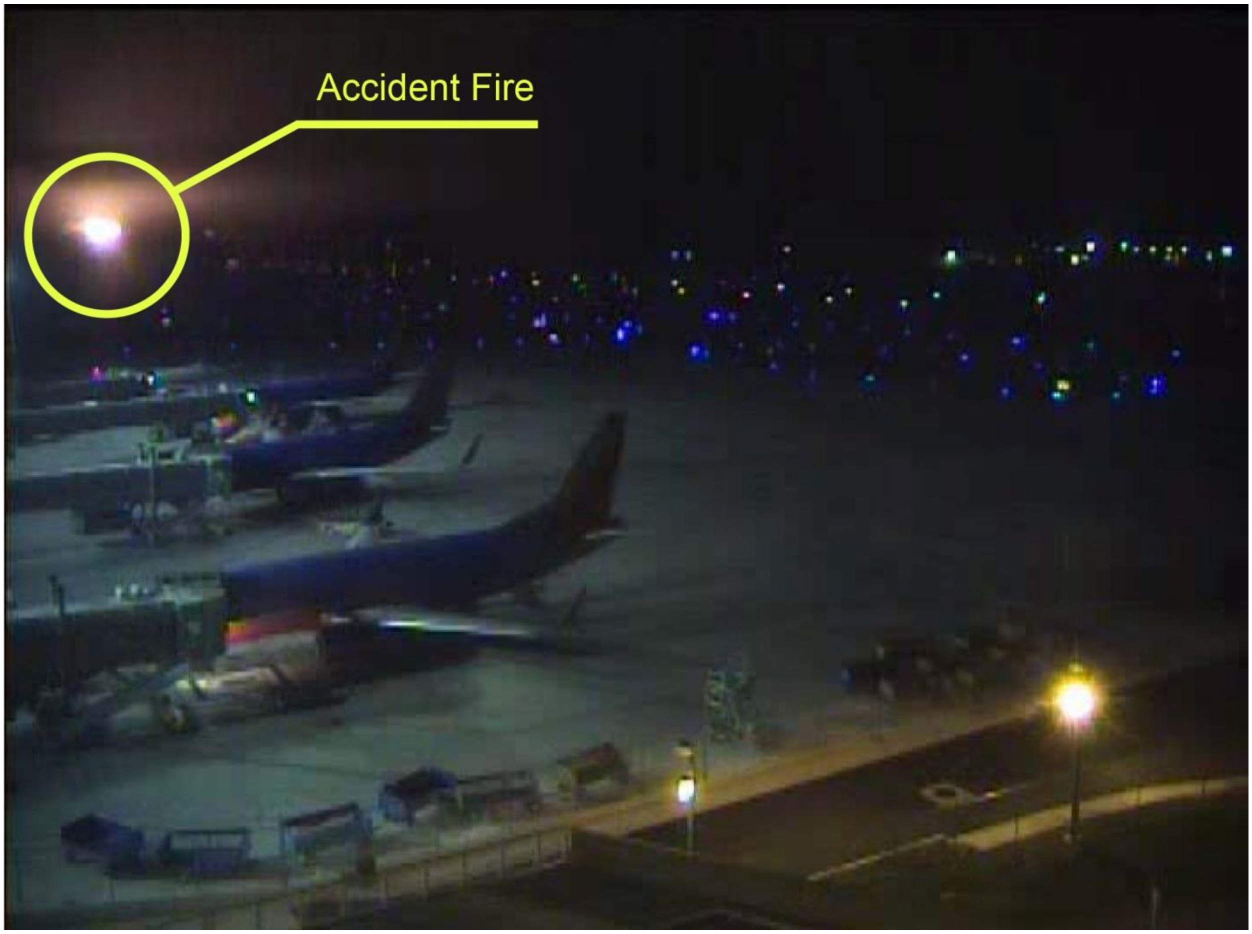


Figure 5. Still-frame photograph from an airport surveillance video camera showing the fire.

1.4 Other Damage

The accident airplane damaged trees and utility poles and lines during its descent, which resulted in minor damage to local properties. Also, aircraft rescue and firefighting (ARFF) personnel cut an opening in a fence so that they could access and apply foam to the wreckage.

1.5 Personnel Information

1.5.1 The Captain

The captain, age 58, was the PF on the accident flight. He held an airline transport pilot certificate with a type rating on the A310,[25] a flight engineer certificate (turbojet), and a flight instructor certificate (airplane single engine, instrument airplane). The captain's current

[25] According to FAA Order 8900.1, Figure 5-88, "Pilot Certification Aircraft Type Designations – Airplane," the A300-600 and A310 are common type ratings.

first-class medical certificate was issued by the Federal Aviation Administration (FAA) on April 16, 2013, and included the limitation, "Must have available glasses for near vision."

Before UPS hired the captain, he was employed by Trans World Airlines as a Boeing 727 flight engineer and then as a 727 first officer. He had previously flown for a regional airline as a flight instructor and in the military; however, the captain's UPS records did not list flight times at his previous employers or his military flight time.

The captain was hired by UPS on October 29, 1990, as a 727 flight engineer and transitioned to a 727 first officer in August 1994. UPS records indicate that the captain attempted to upgrade to Boeing 757 captain twice—in July 2000 and September 2002—but voluntarily withdrew from training during classroom instruction, returning to the position of 727 first officer on both occasions. In April 2004, the captain transitioned to first officer on the A300 and subsequently upgraded to captain on the A300 in June 2009. A review of UPS records[26] indicated that the captain had about 6,406 hours total flight time at UPS, of which 3,265 hours were in the A300. His most recent pilot-in-command line check was accomplished on March 21, 2013, and his most recent proficiency training and check were accomplished on June 26, 2013.

The captain was current and qualified in accordance with UPS and FAA requirements. A review of FAA records found no prior accident or enforcement actions and one incident.[27] A search of records at the National Driver Register found no history of driver's license revocation or suspension. UPS reported the captain had no recorded disciplinary actions.

The UPS training department did not retain the training records for the captain's two uncompleted 757 upgrade attempts. Records indicated that the captain also had multiple failures of home study programs in 1991 and 1992 and that he failed maneuvers validation[28] in 2007. Further, the captain's training records revealed multiple substandard elements[29] related to nonprecision approaches (most recently June 2013). The training deficiencies noted for the captain were during recurrent training, and for those, the company check airman or instructor provides additional training. Because recurrent training involves training to proficiency, it is not unusual for a pilot to repeat an item.

During postaccident interviews, one pilot who had flown with the accident captain described him as "average to above average" in flying ability, stating that he managed the cockpit better than most and accepted input from first officers. Another pilot stated that the captain was a "very normal and standard" pilot, was very routine, and did nothing out of the ordinary. The captain reportedly followed all company procedures, provided good briefings, and

[26] Although the captain reported 8,600 hours of total flight time on his most recent first-class medical application, no documentation of that time was available. Therefore, the times listed here are UPS flight times only.

[27] On August 20, 2010, the captain was involved in an incident in which the A300 he was operating departed a taxiway after landing. According to FAA records, remediation training was accomplished by the UPS A300 chief pilot.

[28] This validation addressed an individual's proficiency in the execution of maneuvers. For a Qualification Curriculum, crewmembers were expected to have reached a satisfactory level of proficiency in the maneuvers before this validation event.

[29] During recurrent training in 2013, the captain was required to redo an item when he set his minimums bug (an adjustable indicator on the barometric altimeter) incorrectly while performing a nonprecision approach. He also had deficiencies noted during his captain upgrade training in 2009 that required repeating or being debriefed on a number of scenarios.

used the appropriate checklists. No pilots interviewed expressed concerns about flying with the captain.

The captain's colleagues indicated that, in the weeks before the accident, the captain had expressed concern that the flying schedules were becoming more demanding.[30] He mentioned that they were flying more legs per night and "day/night flops." He further stated that flying 1 week on then 1 week off made it difficult to get back into a routine the first couple of days of a trip and that the end of the trip was also difficult. He told one colleague, "I can't do this until I retire because it's killing me."

1.5.1.1 The Captain's Preaccident Activities

At the time of the accident, the captain lived in Matthews, North Carolina, with his wife and teenage daughter, and he commuted to the UPS base at SDF. His wife described the captain's health as good and said it had improved in the last 12 months because he had started exercising. He did not smoke, exercised regularly, and drank alcohol occasionally. Although no medications were listed in the captain's FAA medical records, the captain's wife said that he took a prescription medication to treat his high blood pressure and occasionally took vitamins.

The captain was off duty from August 5 to 9, 2013. On August 9, 2013, about 1645, the captain called UPS crew scheduling and reported being sick and cancelled the trip he was scheduled to fly beginning on August 10. He told the crew scheduling technician that he would pick up his scheduled trip on August 13 in SDF.[31]

The captain's wife did not recall when the pilot woke up on Sunday, August 11 but said they went to church that morning before attending the last day of family reunion events. They returned home about 1700, took their daughter to dinner, and watched television. Records show that the captain logged into the UPS crew flight operations system about 1836. The captain's wife could not recall when they went to bed that night but said they usually went to bed between about 2130 and 2200 and watched television for a while.

It is not known when the captain awoke on August 12; however, records show that he logged into the UPS crew flight operations system about 0552 and again about 0859. The captain's wife said that he performed normal activities and took a nap. A records review and device examination showed portable electronic device (PED) activity[32] between 1000 and 1114 then again from 1852 to 2109. The captain logged into the UPS crew flight operations system about 2023, and the captain's wife and daughter then drove him to the UPS facility at Charlotte/Douglas International Airport, Charlotte, North Carolina. The captain commuted to SDF, riding on the jumpseat of a UPS flight, where he arrived about 2232. He requested a sleep

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[30] The CVR recorded similar related comments between the captain and first officer.

[31] According to the captain's wife, she was not aware of any recent illness or injury that precipitated his sick call on August 9. She said that she and her husband participated in nearby family reunion activities throughout the weekend of August 9 to 11. According to UPS records, the captain had called in sick for 15 total days in five occurrences over the previous 13 months. As a result, the pilot's sick call on August 9 triggered a review by the assistant chief pilot, with nothing unusual noted. UPS retains absence records indefinitely.

[32] The captain's PEDs included two cell phones, a tablet, and an e-reader.

room[33] about 2247 and entered the sleep room about 9 minutes (min) later. At 2334 on August 12, the captain accessed photos on his e-reader.

It is unknown whether the captain slept or when he exited the sleep room on August 13. There was a break in his PED activity from 2334 to 0057. About 0057, he used the PED for 3 min. The captain went on duty about 0214, and a colleague and friend reported speaking with the captain about 0230. The accident pilots departed SDF about 0326 and flew to General Downing-Peoria International Airport (PIA), Peoria, Illinois, then to Chicago/Rockford International Airport (RFD), Rockford, Illinois, where they arrived about 0553. The pilots took a hotel shuttle to the hotel, arriving about 0601. Hotel key swipe logs indicate that the captain entered his room about 0621. Data showed periodic PED activity between 0638 and 0656, followed by extended breaks in PED activity between 0656 and 1047, 1048 and 1510, and 1645 and 1835. The captain left his hotel room at some time during the day and returned to his room about 1834. The captain's wife said she spoke with the captain about 1930, and he told her he got sleep during the day.

The accident pilots were picked up by the shuttle about 2006 and went on duty at RFD about 2036. They flew to PIA, then SDF, arriving at SDF about 2357. Upon arrival at SDF, the flight crew took the shuttle to the UPS air services center, where the captain requested a sleep room about 0009 on August 14 and entered the room about 7 min later. Data indicate PED activity from 0024 to 0044. The captain left the sleep room about 0247 and logged into the UPS crew flight operations system about 0254. Records indicate that the accident flight pushed back for departure from SDF about 0355. The captain's preaccident activities are shown in figure 6.

[33] UPS provides rest facilities at SDF, available to pilots on a first-come, first-served basis. The SDF rest facility includes 124 private sleep rooms available for pilot use for up to 12 hours. UPS also provides three "quiet" rooms outfitted with recliners. One of the quiet rooms was more suitable for sleeping, with dimmed lights and blankets available for pilot use. The other two quiet rooms could be used to watch television, read, or perform other activities.

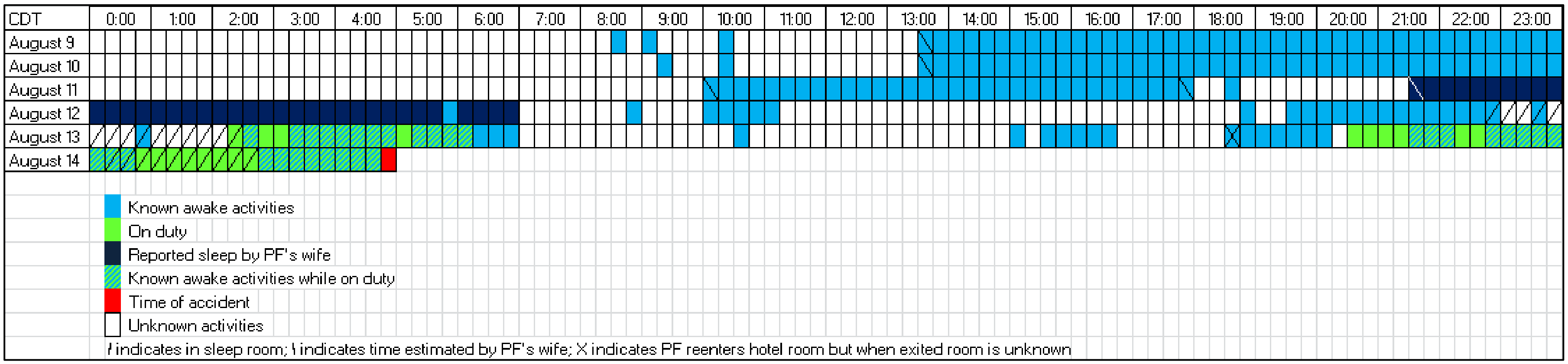


Figure 6. Captain's preaccident activities.

1.5.2 The First Officer

The first officer, age 37, was the PM on the accident flight. She held an airline transport pilot certificate with numerous type certificates, including a type rating on the A310 (second-in-command) and a flight engineer certificate (turbojet). The first officer's current first-class medical certificate was issued by the FAA on January 7, 2013, and included no limitations.

Before being hired by UPS, the first officer flew for corporate and regional operators. UPS hired her as a 727 flight engineer on November 16, 2006. She upgraded to a 757 first officer in October 2007, then transitioned to the Boeing 747-400 and was based at Ted Stevens Anchorage International Airport, Anchorage, Alaska, in June 2009. On June 7, 2012, she transitioned to the A300 and was based at SDF. According to UPS records, at the time of the accident, the first officer had about 4,721 hours of total flight time, including 403 hours as second-in-command in the A300. Her most recent proficiency training and check were accomplished on June 26, 2013.

The first officer was current and qualified in accordance with UPS and FAA requirements. A review of FAA records and Pilot Records Improvement Act[34] records on file with UPS revealed no accident, incident, or enforcement history. A search of the National Driver Register found no history of driver's license revocation or suspension. UPS reported the first officer had no recorded disciplinary actions.

UPS records showed that the first officer called in sick six times in the 13 months before the accident; four of those calls were made in 2013, most recently on July 14, 2013. She was contacted by her assistant chief pilot after a sick call on March 20, 2013, and again after the most recent sick call. She provided her assistant chief pilot with a doctor's note in March and said she had a doctor's appointment in July. The assistant chief pilot said he found nothing unusual about her most recent sick call.

One pilot who flew with the first officer described her as a "top notch person" who was very approachable and as a professional aviator who followed procedures. Another pilot who flew with the first officer stated that she was efficient, did her job, was on time, was someone you could depend on, and used the procedures as trained. No pilots who were interviewed were concerned about flying with the first officer or with her crew resource management (CRM) skills, and all of them believed that she would speak up to a captain if necessary.

In the context of schedule-related discussions with her husband, the first officer had indicated that cargo pilots were increasingly being "pushed." The first officer had spoken to her husband in the past about being tired at the end of the day, but he said that, if she was not able to, she would not fly. However, a colleague of the first officer stated that he did not think she would call in fatigued; he said she was more of the type to "fly under the radar." She had told the colleague within the month before the accident that she had been having trouble staying awake in

[34] The Pilot Records Improvement Act requires that a hiring air carrier under 14 CFR Parts 121 and 135, or a hiring air operator under 14 CFR Part 125, request, receive, and evaluate certain information concerning a pilot/applicant's training, experience, qualification, and safety background before allowing that individual to begin service as a pilot with their company. The act went into effect in 1996. The captain was hired by UPS on October 29, 1990, and thus was not subject to a pilot records improvement act check.

the cockpit. He stated it was something that had become an epidemic among flight crews and indicated that the first officer and her colleague frequently discussed how the schedules had deteriorated and crews were flying more legs.

A pilot walking through the SDF "ready room" in March 2013 saw the first officer with her face down on the table. She told him that she was "totally exhausted" and that, although she had a sleep room, it was an exterior room. The pilot indicated to investigators that the exterior rooms were noisier than the interior rooms. He encouraged her to call in fatigued. Another pilot who recently flew with the first officer on a week-long trip stated that, toward the end of the week, although she was responding to radio calls, she was "zoning out" during the cruise portion of the flight. He commented to her that she looked tired, and she told him she was a little tired.

1.5.2.1 The First Officer's Preaccident Activities

At the time of the accident, the first officer lived in Lynchburg, Tennessee, with her husband, and she commuted via car to the UPS base at SDF. The first officer's husband said she was "as healthy as you get" and although she did not exercise regularly, she worked with her horses a lot and got a "farm workout." She did not take any prescription medication but took vitamins daily. She drank alcohol rarely and did not use tobacco products. She had no recent illness or injuries. The first officer's husband reported that, when she was off duty, she tried to be in bed by about 2000. She would sleep through the night and awake about 0600 to 0700. She had no major changes to her health, financial situation, or personal life that would have impacted her performance on the day of the accident.

The first officer was off duty from August 4 to 9. Although it is not known what time the first officer commuted from her home in Tennessee to SDF on August 9 to report for duty on August 10, her husband reported that SDF was about 3 1/2 to 4 hours driving time from their home.

The first officer's PED data[35] indicated usage from 2346 on August 9 to 0259 on August 10. On August 10, the first officer went on duty about 0256. The first officer's flight departed SDF about 0357 and arrived at San Antonio International Airport (SAT), San Antonio, Texas, about 0610. About 0625, the first officer went off duty for about 62 hours 30 min. During this off-duty period, the first officer traveled (using jumpseat privileges on Southwest Airlines) from SAT to William P. Hobby Airport (HOU), Houston, Texas, to visit a friend, arriving in Houston about 1105 on August 10. PED data showed periodic activity between 0942 and 1323, followed by a break in activity from 1324 to 1506. PED activity resumed about 1507 with no extended breaks until 2327. It is unknown when the first officer went to bed or awoke on August 11.

Although it is not known when the first officer awoke on August 11, records show her PED activity began about 0858 and continued throughout the day with several extended breaks. Her husband said she texted him during the day and told him she was resting. She said she was tired and felt bad that she was not able to spend as much time with her friend because she was sleeping the whole time. PED activity continued from 2344 until 0117 on August 12 and then

[35] The first officer's PED included a cell phone and a tablet.

resumed about 0744. The first officer logged into AirUPSers.com[36] about 0927 and the UPS crew flight operations system about 0942. There was a break in activities until 1044, and the first officer departed HOU for SAT about 1325. PED data indicated activity from 1401 to 1720. A break in activity occurred from 1720 to 1841, when PED activity resumed. According to a friend who spoke to the first officer on August 12, she told him via text that she would "pay big money to sleep" but that it was time for her to get ready. The first officer departed the hotel for SAT about 2030 and began her duty day about 2053, arriving at SDF about 0022 on August 13.

After arriving at SDF, the first officer talked with a colleague in the crew briefing room about 0025, briefly engaged in PED activity, and logged into the UPS crew flight operations system about 0037 and 0106. Her activities between 0106 and her departure from SDF about 0326 are unknown; no sleep room was secured. The accident flight crew departed for RFD via PIA, arrived in RFD about 0553, and checked into the hotel in Rockford about 0601. A review of the hotel's key swipe logs indicated that the first officer entered her hotel room about 0620.

The first officer logged into the UPS crew flight operations system about 0642 and engaged in PED activity between 0645 and 0649. A break in PED activities occurred from 0649 to 1043. A member of the hotel staff reported speaking with the first officer in the hotel restaurant about 1100. PED activity stopped about 1148 and resumed from 1343 to 1705. Hotel key swipe logs indicated that the first officer reentered her room about 1522. PED activity resumed about 1827. The first officer spoke to her husband about 1915, and he said that it was a regular conversation and that she did not discuss how she was feeling or how she slept. The accident flight crew departed the hotel for the airport about 2006, and the first officer went on duty about 2036. PED activity resumed from 2106 to 2124, and, 10 min later, the flight crew departed RFD for SDF via PIA, arriving in SDF about 2357.

Upon arrival in SDF, the flight crew took the shuttle to the air services center about 2358. The first officer logged into the crew flight operations system about 0009 on August 14 and checked in to a sleep room about 0011. She spoke to a colleague in the briefing room about 0020 before entering the sleep room about 0048. PED activity stopped about 0050. About 0241, closed circuit television footage showed the first officer exit the sleep room. The flight crewmembers took the shuttle to the airplane about 0306, and they pushed back from the gate at SDF about 0355. The first officer's preaccident activities are shown in figure 7.

[36] AirUPSers.com is a website for UPS employees in the company's flight district, particularly pilots, that features flight-related news and information and several job aids, such as route cards for international flights.

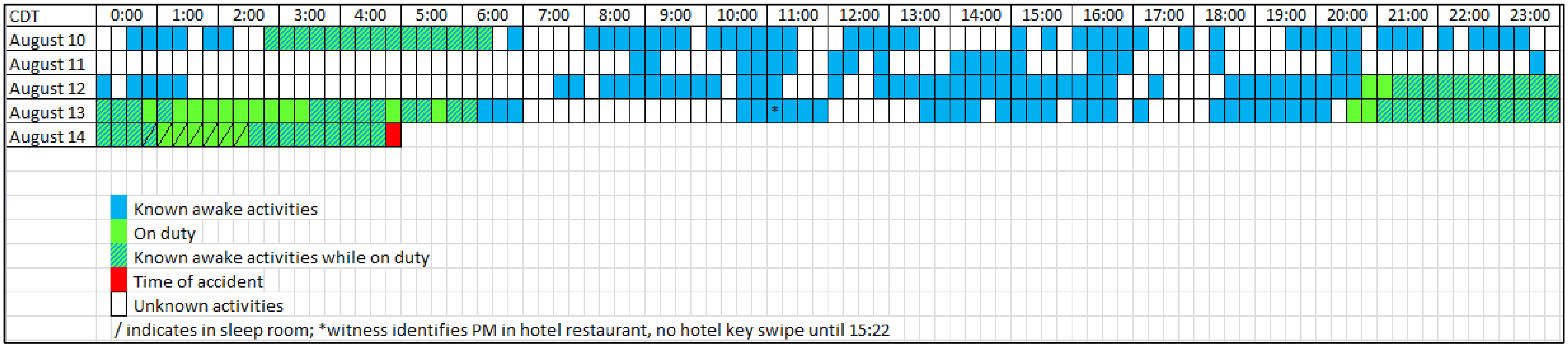


Figure 7. First officer's preaccident activities.

1.5.3 The Flight Dispatcher

The flight dispatcher, age 53, was hired by UPS on June 4, 2012. According to UPS records, before being hired by UPS, the dispatcher had been employed as an independent consultant for Atlas Air Worldwide and Baltia Air Lines since 1998. During most of that time, the dispatcher was also the director and senior manager of flight dispatch operations at Atlas Worldwide Holdings. On his application for employment at UPS, the dispatcher stated that he left Atlas because of company layoffs. The dispatcher received his dispatcher training from Phoenix East Aviation in 1996. He held an FAA aircraft dispatcher certificate dated December 7, 2005.[37]

1.6 Aircraft Information

1.6.1 General Information

The airplane was an Airbus A300 F4-622R that was built in 2004, registered to UPS, and held a transport-category airworthiness certificate dated March 24, 2004. Powered by two Pratt & Whitney PW4158 turbofan engines, the airplane was configured for cargo transport. It was equipped with two pilot seats and one observer seat in the cockpit and four forward-facing passenger jumpseats on the right side of the cabin just aft of the cockpit.

According to the weight and balance form and the flight release information found on the accident airplane, the airplane's estimated landing weight at BHM was about 291,577 lbs, including 34,650 lbs of fuel and 89,227 lbs of cargo. The airplane's landing weight limit was 308,650 lbs. The forms also indicated that the airplane's center of gravity was within limits. There were no unresolved maintenance discrepancies in the airplane's maintenance records.

1.6.2 Airplane Components, Systems, and Records

1.6.2.1 Flight Management System, Flight Management Computer, and Control Display Unit

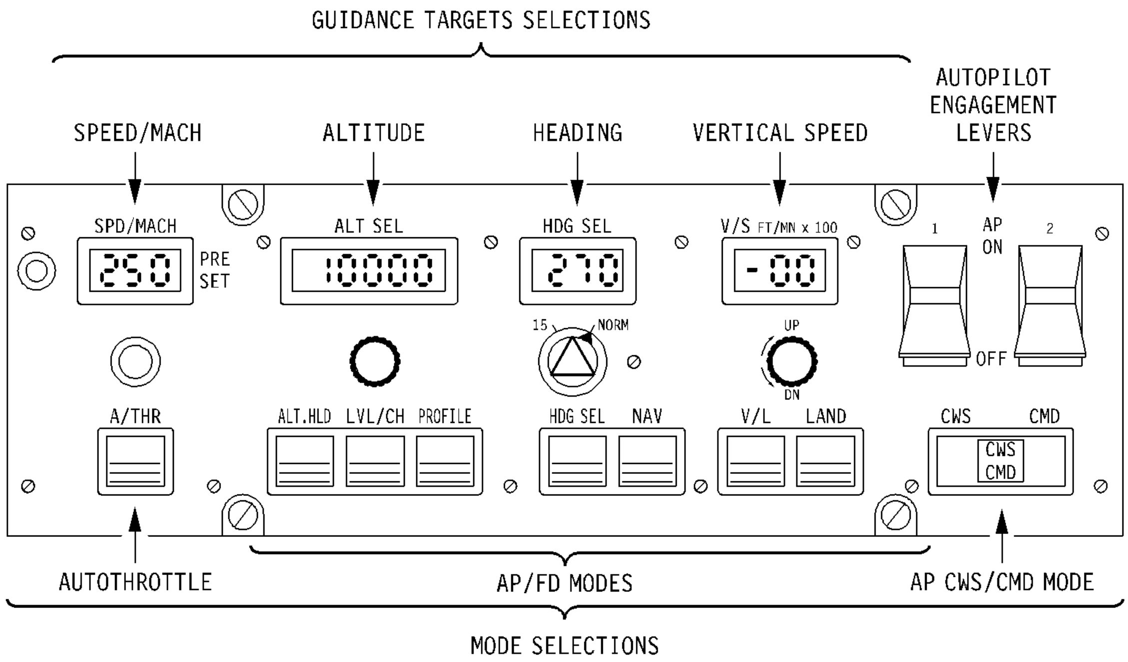
The airplane was equipped with a flight management system, which provided automation of all the navigation and flight management tasks. The flight management system integrates the FMC with many aircraft subsystems. According to the Airbus Flight Crew Operating Manual (FCOM) and the UPS A300 Systems Manual, these subsystems are designed to allow the flight crew to select the desired level of automation and to help control the lateral and vertical flightpath of the aircraft. The FMC also performs optimization and in-flight fuel monitoring and predictions and, as a secondary function, provides data relative to the flight plan for display on the navigation display (ND) for orientation and situational awareness.

The FMC combines flight plan information entered by the flight crew, information stored in the FMC database, and data received from the supporting flight management system

[37] UPS dispatchers are certified under the provisions of 14 CFR 65.55, "Knowledge Requirements" and 14 CFR 65.57, "Experience or Training Requirements," and qualified to dispatch under 14 CFR 121.463, "Aircraft Dispatcher Qualifications."

subsystems. The computer uses this information to calculate the airplane's present position relative to the flightpath selected by the flight crew. With this information, the FMC calculates vertical and lateral guidance including thrust target and updates the navigation data, flight plan corrections, navigation adjustments, and thrust to maintain the aircraft on the flight plan.

The primary crew interface with the FMC is through the mode control panel and two control display units (CDU) (see figures 8 and 9). The navigational information selected by the flight crew is displayed on two NDs and two CDU displays. The two CDU displays are located on each side of the pedestal in front of the throttle levers (see figure 9).[38]

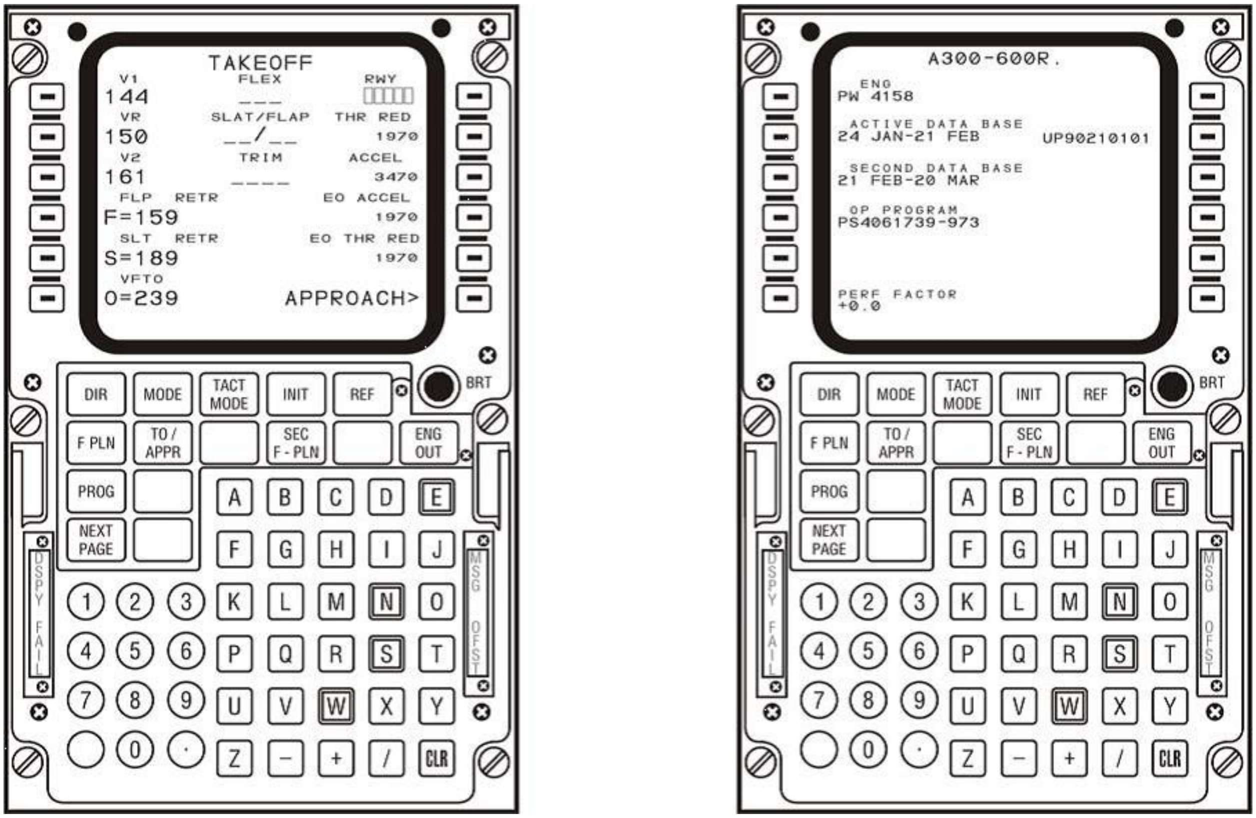


(Source: Airbus A300 FCOM, section 1.03.12.)

Figure 8. A300 mode control panel.[39]

[38] For more information about the CDU, see Attachment 26: A300 Flight Management System of the Operations Group Chairman Factual Report in the public docket for this accident, which is available at www.ntsb.gov.

[39] In the Airbus A300 FCOM, section 1.03.12, "Autoflight System AFS—Pilot Interface," the panel is called the flight control unit. For consistency with UPS manuals and guidance, the term "mode control panel" is used in this report.



(Source: UPS A300 Systems Manual, section 12.01.03, "CDU.")

Figure 9. A300 control display unit.

An FMC mode[40] can be armed or engaged by pressing the corresponding pushbutton on the mode control panel. If a mode is armed or engaged, pressing its pushbutton switch a second time disarms or disengages the mode. Turning a selector knob on the mode control panel clockwise increases the target value, and turning it counterclockwise decreases the target value. The pushbuttons include three green bars that illuminate green when the corresponding mode is armed and stay green when engaged.

The two FMCs were recovered from the wreckage debris field. Data were recovered from one of the system's mass memory cards, which contained information from both FMCs because the FMCs were set to dual operation. The following information, in part, was decoded from the downloaded data:

- The flight plan showed a discontinuity between KBHM and COLIG, which would prohibit the engagement of a profile approach.[41]

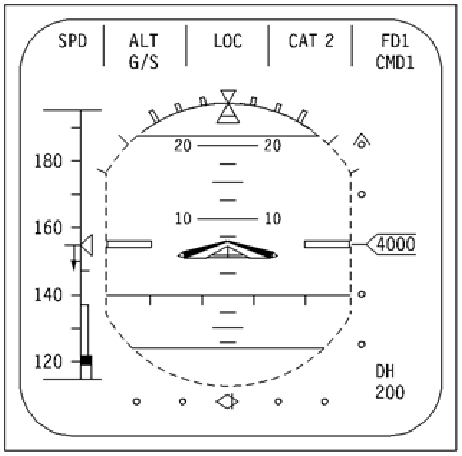
[40] Lateral and vertical (longitudinal) modes typically refer to the type of function that the autopilot/flight director system is controlling.

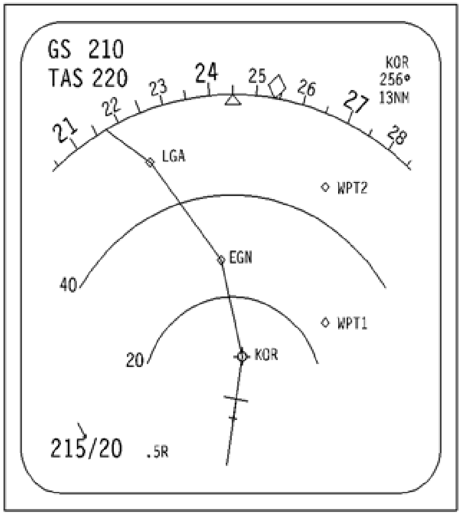
[41] The flight plan was such that it prevented the engagement of the profile mode at this time.

- Neither the "profile mode armed" nor the "profile mode engage" bits[42] were set when the power was lost.
- Vertical and lateral navigation modes were not engaged when the FMC lost power.

1.6.2.2 Primary Flight Display and Navigation Display

The UPS A300 uses two upper primary flight displays (PFDs) and two lower NDs to display most of the data needed for flightpath and navigation monitoring. One PFD/ND pair is located on each side of the cockpit for the captain and first officer (see figure 10).





(Source: Airbus A300 FCOM, sections 1.10.20 and 1.15.24.)

Figure 10. PFD (top screen) and ND (bottom screen).

[42] The profile mode's status is stored in the FMC nonvolatile memory as a logical state (a bit) when the profile mode is armed.

The flight mode annunciator at the top of each PFD provides annunciation of the various autoflight system modes. The flight mode annunciator is divided into as many as five sections depending on the operational mode of the autoflight systems. Modes displayed in green are active, and modes displayed in blue are armed.[43] The flight mode annunciator is the primary source of information to the crew regarding the status of the autoflight system, including the active and armed autothrust, autopilot, and flight director modes.

Selected speed and altitude are indicated on the PFD, and selected heading is indicated on the ND. When immediate time constraints preclude making inputs to the FMC through the CDU, the mode control panel is the short-term interface between the flight crew and the flight management system. The flight crew can arm and engage guidance for vertical and lateral navigation, aircraft speed, and altitude through the mode control panel. The flight mode annunciator is the primary source for verification of the active and armed modes of the autopilot and flight director.

1.6.2.3 Mode Control Panel

According to the UPS A300 AOM, when the autopilot is engaged, the PF should make all mode control panel mode selections except setting the altitude, which is done by the PM. The PF then manipulates the mode control panel to climb or descend to that new altitude.

The AOM recommends verbalizing mode control panel changes to increase the PM's situational awareness. The AOM further recommends that the PM make all mode control panel selections at the PF's direction when the autopilot is not engaged and that the PM should repeat the PF's commands to ensure that the proper command was executed. The primary method of making mode selections is using the associated mode control panel mode pushbutton switch.

1.6.2.4 Autopilot/Autothrottle Operation

According to the UPS A300 AOM, when disengaging the autopilot or autothrottles, the PF must verbally state that the autopilot/autothrottles are being disengaged to ensure that both pilots are aware of the autoflight system status. It further stated, if the autopilot is not providing precise airplane control or maintaining the desired flightpath, the PF must immediately disconnect the autopilot and assume manual control of the airplane. After the airplane flightpath is stabilized, the autopilot may be reengaged if desired.

1.6.2.5 Enhanced Ground Proximity Warning System

The airplane was equipped with a Honeywell EGPWS, which was installed in February 2004. The installation complied with 14 CFR 121.354, "Terrain Awareness and Warning System [TAWS]," pertinent technical standard orders (TSO), and supplemental type

[43] For more information about flight mode annunciator mode indications, see Attachment 26: A300 Flight Management System of the Operations Group Chairman Factual Report in the public docket for this accident, which is available at www.ntsb.gov.

certificates.[44] The EGPWS provides two types of alerts: caution and warning.[45] Caution alerts call attention to the aircraft state or presence of terrain but do not issue a command to the pilot; these alerts include "sink rate," "don't sink," "too low terrain," and "terrain ahead" alerts, among others. Warning alerts call attention to terrain or obstacles and also issue a command to the pilot; these alerts include the "pull up," "terrain, terrain, pull up," "terrain ahead, pull up," and "obstacle ahead, pull up" alerts.

Accident data showed that the EGPWS provided a "sink rate" caution alert at 0447:24.5 when the airplane was descending through about 250 ft agl at a vertical speed of about 1,500 fpm. The captain then reduced the airplane's descent rate. About 8 seconds later, the CVR recorded the first sounds of the airplane impacting trees, and, 1 second later, the EGPWS provided a "too low terrain" caution alert.

The investigation determined that a version of the Honeywell EGPWS software (part number 965-0976-003-218-218) newer than that used on the accident airplane improves the terrain clearance floor alert envelope[46] and provides earlier alerts.[47] Examination of the radio altitude relative to the distance to the runway threshold for the accident flight indicated that the newer EGPWS software would have provided a "too low terrain" caution alert about 6.5 seconds earlier and 150 ft higher than the EGPWS software installed in the airplane. However, because of the high descent rate of the airplane, simulator testing showed that the effectiveness of the terrain clearance floor envelope would be compromised, even with the newer EGPWS software. Simulator tests and a performance study were completed based on the new EGPWS software to determine if a response to the "too low terrain" caution alert would have enabled the pilots to avoid impacting the trees.[48] Results showed that, if a pilot applied aggressive manual inputs to avoid terrain within 2.4 seconds of the alert or if a pilot pressed the automated takeoff/go-around switch on the throttles within 0.6 second of the alert, it was possible to avoid terrain.[49] For additional information on UPS guidance on appropriate pilot responses to EGPWS alerts, see section 1.17.3.

[44] The EGPWS model installed on the accident airplane was designed to provide terrain alerts to pilots based on a combination of airplane information (such as geographic position, attitude, altitude, and airspeed) and database information about terrain, obstacles, and the landing runway. The EGPWS used these inputs to predict a potential conflict between the airplane's flightpath to the runway and terrain or obstacles and provided a visual and audio caution or warning alert if such a conflict was detected.

[45] A caution alert has a lower priority than a warning alert. According to the UPS AOM, "All warning alerts require that the crew immediately perform the controlled-flight-into-terrain…recovery maneuver, except under the following conditions: the terrain alert occurs during day visual meteorological conditions, and the flight crew can immediately and unequivocally determine that terrain clearance is not a factor." The UPS AOM further indicated, "When any GPWS/EGPWS alert is activated, regardless of its duration, or if a situation is encountered resulting in unacceptable flight toward terrain, take immediate and positive corrective action."

[46] The terrain clearance floor alert is a function of the airplane's radio altitude and distance relative to the center of the nearest runway in the database. It enhances the basic EGPWS by alerting the pilot of descent below a defined "terrain clearance floor" regardless of the aircraft configuration.

[47] On July 30, 2014, the UPS party representative stated that the EGPWS software on UPS airplanes will be upgraded to the newer version.

[48] Performance data also showed that had the captain performed the controlled-flight-into-terrain-avoidance maneuver or a go-around in response to the "sink rate" alert, the airplane could have avoided terrain.

[49] These times are measured from the time the alert sounds to the time the pilot decides to take action (perception/reaction time); therefore, they account for the time it takes for the pilot to decide to act and then move his or her hands to the appropriate controls (for example, to advance the throttles manually or to press the takeoff/go-around switches).

To reduce nuisance alerts, some Honeywell EGPWS alert modes are desensitized when the airplane is in landing configuration or within 2 miles of the airport. For example, the Mode 2 “Excessive Terrain Closure Rate” alert envelope[50] is smaller when the airplane is configured for landing and when descent rates are higher. The radio altimeter data are also filtered to eliminate nuisance warnings, which further reduces the envelope. Also, the EGPWS terrain look-ahead alert mode is desensitized because nuisance alerts would occur due to technology limitations.[51] Because of these factors, no Mode 2 or terrain look-ahead alerts were generated for the accident flight.

Additionally, the EGPWS on the accident airplane was manufactured in accordance with TSO-C151A, issued in 1999, which included a requirement for a 500-ft callout capability. The TSO was revised in 2012 (TSO-151C) and emphasized that TAWS equipment must provide a 500-ft voice callout when the airplane descends to 500 ft above the terrain or nearest runway elevation. The EGPWS was capable of producing the callout, but the 500-ft callout had not been activated on the accident airplane. An Airbus standard is to use the flight warning computer (FWC) for callouts in lieu of the EGPWS callouts, but operators may implement any Honeywell EGPWS altitude/height callouts at their discretion.

1.6.2.6 Altitude Callouts

On the Airbus A300, many operators use a 400-ft callout generated by the FWC in lieu of the EGPWS 500-ft callout. Airbus also offers its customers the option of an automated height-above-touchdown callout of “minimums”[52] intended to activate when an airplane flying a nonprecision approach reaches the pilot-entered minimum descent altitude. However, UPS did not have these callouts activated on its A300 fleet. If activated, an automated aural “approaching minimums” alert would have sounded at 0447:17, which was 20.8 seconds before impact. An automated 500-ft callout would have sounded at 0447:14, about 18.5 seconds before impact. Additionally, the aural “minimum” alert would have sounded at 0447:16, about 16.5 seconds before impact (the 400-ft callout also would have activated about this time).

1.6.2.7 Flight Crew/System Interaction During an Instrument Approach

Nonprecision Approaches

An instrument approach procedure defines a three-dimensional trajectory that will guide an aircraft from the en route airspace structure down to a point where a pilot can accomplish a landing using visual references outside the airplane. The pilot can guide the airplane along this trajectory solely by reference to the airplane’s instruments and displays so that outside visual references are not required until the end of the trajectory is reached. At the end of the trajectory

[50] The Mode 2 “Terrain Closure Rate” alert provides alerts to help protect the airplane from impacting the ground when the EGPWS detects that the airplane is rapidly approaching terrain.

[51] The terrain look-ahead alert mode provides the ability to look ahead of the airplane and detect terrain or obstacle conflicts to provide greater alerting time. This is accomplished based on airplane position, flightpath angle, track, and speed relative to the terrain forward of the airplane contained in the terrain database. Within close proximity to the ground, small errors in the airplane’s position and in the terrain database are accentuated, thus creating nuisance alerts.

[52] It is standard UPS operating procedure on nonprecision approaches for the PM to announce “approaching minimums” at 100 ft above the minimum descent altitude and “minimums” at the minimum descent altitude.

(called the "missed approach point"), the pilot must decide to either land (if the runway environment has been visually acquired and the airplane is in the proper configuration and state for landing) or, if these conditions are not met, perform the missed-approach procedure. If the autopilot is used to fly the approach and/or missed-approach procedures, the pilot must still monitor the airplane's instruments to ensure that the desired trajectories are being followed.

During a nonprecision approach, the pilot uses the barometric altimeter to ensure that the airplane is at or above the minimum altitude defined between approach fixes; once a fix is crossed, the pilot can "step down" to the lower minimum altitude. The "minimum descent altitude" for the approach is the lowest altitude to which the airplane may descend before reaching the missed approach point. Once past the final step-down fix, an aircraft may descend to the minimum descent altitude but no lower. If the pilot can then see the runway environment before reaching the missed approach point and believes a landing can be accomplished, he or she can descend below the minimum descent altitude and attempt the landing. If the pilot does not see the runway environment, the airplane must remain at or above the minimum descent altitude and, upon reaching the missed approach point, the pilot must execute the missed-approach procedure.

Lateral and Vertical Path Guidance on Final Approach

When the airplane is aligned with the runway heading and approaching the runway during final approach, both precision and nonprecision approaches provide lateral guidance information that the airplane's systems use to display to the pilot the airplane's position to the left or right of the desired track (that is, its "lateral deviation"). This guidance information can be ground-based (such as the localizer beam used for the BHM runway 18 localizer approach) or GPS-based (as used for the various RNAV approaches to the runways at BHM).

Whether ground- or GPS-based, the lateral deviation information is presented to the pilot as a horizontal scale with a vertical diamond. The position of the diamond indicates the position of the desired track relative to the airplane. Thus, if the diamond is in the center of the horizontal scale, the airplane is on the desired track; if the diamond is to the left of center, the airplane is to the right of the desired track and must correct to the left. If the diamond is on the left or right limit of the scale, it is at "full deflection" or "pegged." A pegged diamond indicates that the airplane is far off course but does not provide a measure of exactly how far; a deviation that is just large enough to peg the diamond appears as half a diamond.

Precision approaches also provide ground-based vertical guidance information used by the airplane's systems to display the airplane's position above or below the desired glidepath to the touchdown point. This vertical guidance is typically an instrument landing system (ILS) glideslope, and the airplane's position relative to the glideslope is presented to the pilot as a vertical scale with a horizontal needle (the glideslope diamond). The position of the diamond indicates the vertical position of the glideslope relative to the airplane.

When flying a precision approach, a primary task of both pilots is to constantly scan the horizontal and vertical deviation and make immediate corrections to keep the airplane centered on the desired lateral and vertical flightpaths. For many operators, large lateral or vertical deviations on final approach are considered indicators of an unstabilized approach and serve as triggers for executing the missed-approach procedure.

When flying a nonprecision approach with vertical guidance, a primary task of both pilots is to constantly cross-check the vertical deviation diamond on the vertical scale to ensure that the airplane remains on the flightpath. In the case of a localizer approach with a vertical guidance, the pilot must also make flightpath corrections as necessary to keep the lateral and vertical deviation diamonds centered.

"Dive and Drive" Final Approach Technique

As mentioned earlier, nonprecision approaches do not provide ground-based vertical guidance information, and some, such as localizer approaches and some RNAV approaches also do not provide GPS-based vertical guidance.[53] For these approaches, there is no source of information from outside the airplane (such as a glideslope or GPS signal) that can be used to determine the airplane's position relative to the desired glidepath or display any deviation from that glidepath to the pilot. Instead, vertical guidance is provided via altitude step-down fixes depicted on the approach chart, and the pilot uses navigation aids and the barometric altimeter to stay at or above the minimum altitude at each step.

Consequently, nonprecision approaches can result in variations in the airplane's descent rate and flightpath angle between the FAF and the runway, as the pilot levels off between step-down fixes and then resumes the descent after reaching the next step-down fix. For example, for the BHM localizer 18 approach, if an airplane descended at a flightpath angle steeper than 3.28° after passing BASKN, the airplane would reach an altitude of 1,380 ft before reaching the IMTOY stepdown fix and would have to level off at 1,380 ft until passing IMTOY. Then the pilot could resume the descent to the minimum descent altitude of 1,200 ft. If the airplane descended to 1,200 ft before reaching the missed approach point, the pilot would have to again level the airplane at 1,200 ft, looking for the runway while approaching the missed approach point. If the pilot saw the runway before reaching the missed approach point, the airplane could then descend once again, and the pilot could attempt the landing. This stair-step approach to the runway is commonly referred to as a "dive and drive" technique. According to Advisory Circular (AC) 120-108, "Continuous Descent Final Approach [CDFA]" guidance, "Stepdowns flown without a constant descent will require multiple thrust, pitch, and altitude adjustments inside the final approach fix (FAF). These adjustments increase pilot workload and potential errors during a critical phase of flight."

Continuous Descent Final Approach Technique and Stabilized Approaches

The CDFA technique (or constant-angle-of-descent technique) is a specific technique for flying the final approach segment of a nonprecision instrument approach as a continuous descent, without level-off, from an altitude/height at or above the FAF minimum crossing altitude/height to a point about 50 ft (15 meters) above the landing runway threshold or the point where the flare maneuver should begin for the type of aircraft flown.

The National Transportation Safety Board (NTSB) has long been a proponent of the CDFA technique for nonprecision approaches and of promoting pilot proficiency in conducting

[53] Some RNAV approaches do provide GPS-based vertical guidance information. For these approaches, the vertical deviation from the desired glidepath to the runway is presented to the pilot in much the same way as glideslope deviation information is presented for an ILS approach.

nonprecision approaches. After investigating numerous accidents related to nonprecision approaches (NTSB 1991, 1996, 2000),[54] the NTSB noted that the complexity of such approaches and the absence of precise vertical guidance create more demands on pilot skills and cognitive performance than precision approaches. Additionally, pilots have less opportunity to conduct nonprecision approaches. As a result, on January 27, 2000, the NTSB issued Safety Recommendation A-00-11, which asked the FAA to do the following:

> Issue guidance to air carriers to ensure that pilots periodically perform nonprecision approaches during line operations in daytime visual conditions in which such a practice would not add a risk factor.

On August 21, 2001, the FAA responded that it had developed an industry-wide strategy that focused on stabilized approaches, including always using a constant angle of descent, for all nonprecision approaches. The FAA issued general guidance regarding stabilized approaches in AC 120-71 and through Flight Standards Information Bulletins for Air Transportation 00-08, 99-08, and 00-18.

On January 23, 2002, the NTSB indicated that the use of a constant-angle-of-descent stabilized approach profile when conducting nonprecision approaches eliminated the need for flight crews to periodically perform nonprecision approaches during line operations. Consequently, the NTSB determined that the FAA's issuance of this guidance material addressed Safety Recommendation A-00-11 through alternate actions and classified Safety Recommendation A-00-11 "Closed—Acceptable Alternate Action."

In 2004, near Kirksville, Missouri, the pilots of Corporate Airlines flight 5966 failed to follow established standard procedures during a nonprecision approach at night in IMC, including their descent below the minimum descent altitude before required visual cues were available, which continued until the airplane struck the trees (NTSB 2006). The NTSB concluded that the use of a constant-angle-of-descent approach technique, with its resultant stabilized, moderate rate-of-descent flightpath and obstacle approach clearance, would have better positioned the accident airplane for a successful approach and landing. Therefore, the NTSB issued Safety Recommendation A-06-8, which asked the FAA to do the following:

> Require all 14 *Code of Federal Regulations* Part 121 and 135 operators to incorporate the constant-angle-of-descent technique into nonprecision approach procedures and to emphasize the preference for that technique where practicable.

On May 21, 2009, the FAA issued Safety Alert for Operators (SAFO) 09011, which recommended that 14 CFR Part 121 and 135 operators always use a constant-angle-of-descent stabilized approach technique when conducting nonprecision approaches. On January 12, 2009, and May 20, 2011, the FAA published a notice of proposed rulemaking and a supplemental notice of proposed rulemaking (SNPRM), respectively, titled "Qualification, Service, and Use of Crewmembers and Aircraft Dispatchers," which proposed a requirement for 14 CFR Part 121

[54] The NTSB found similar nonprecision approach-related factors in the Aeronautica Civil, Republica de Colombia investigation of the 1995 accident involving an American Airlines Boeing 757 on a nonprecision approach to Cali, Colombia; and the 1989 accident investigated by the Malaysia Department of Civil Aviation involving a Flying Tigers Boeing 747 that crashed while performing a nonprecision approach to Kuala Lumpur, Malaysia.

operators to train and incorporate the constant-angle-of-descent technique into their nonprecision approach procedures.

On November 14, 2012, the NTSB indicated that it agreed with the FAA that the SNPRM (if it resulted in a satisfactory final rule) satisfied this safety recommendation with regard to Part 121 operators and that SAFO 09011 satisfied the recommendation with regard to Part 135 operators. Therefore, pending the issuance of a final rule as described in the SNPRM and a review of information confirming that SAFO 09011 has been widely adopted by the Part 135 community, the NTSB classified Safety Recommendation A-06-8 "Open–Acceptable Alternate Response." However, the final rule, which was published on November 12, 2013, did not contain any requirements regarding nonprecision approach techniques.

On January 20, 2011, the FAA issued AC 120-108, "Continuous Descent Final Approach," to promote the technique of a stable continuous descent path to the minimum descent altitude in lieu of the traditional "dive and drive"[55] type of nonprecision approach; however, an AC is not mandatory and only provides guidance. According to AC 120-108, the CDFA operating concept is to fly nonprecision instrument approaches at a continuous descent rate maintaining the published nominal vertical profile using basic piloting techniques, aircraft flight management system and RNAV systems. They can use altitude-versus-range points defined by a distance measuring equipment fix, crossing radial, or GPS distance from the runway on the approach plate to track their progress along both the lateral and vertical approach paths to the missed approach point. The most critical aspect of CDFA is that when a missed approach is conducted, the pilot executes a missed approach at the minimum descent altitude plus an additive buffer altitude (to prevent descent below minimum descent altitude) instead of leveling off at the minimum descent altitude. The AC also states that, based on near-term safety benefits (such as controlled flight into terrain [CFIT] reduction) of using stabilized approach criteria on a continuous descent with a constant, predetermined vertical path to the runway and the desire to move to three-dimensional operations where possible, operators have indicated their intent to apply the CDFA technique to nonprecision instrument approaches.

The A300 Profile Final Approach Mode

The Profile Final Approach mode ("profile mode") on the A300 autopilot flight director system approximates a CDFA. It uses the airplane's FMC to compute a desired glidepath extending from a point above the runway threshold[56] along the approach course and displays the airplane's vertical deviation from this glidepath to the pilot using a vertical scale and diamond (the vertical deviation indicator [VDI]). The UPS A300 PTG, section 02.04.01.01, "Non-Precision Approaches—General," outlines the advantages of the profile mode over a "dive-and-drive" technique for conducting nonprecision approaches, stating, in part, the following:

> Executing a nonprecision instrument approach is one of the most demanding tasks placed on a flight crew. The safe execution of nonprecision approaches places increased challenges on the aircrew in the areas of:

[55] The AC describes the "dive and drive" concept as a situation in which an aircraft remains "at the minimum descent altitude until descending for the runway or reaching the missed approach point."

[56] Typically, the height of this point above the runway is the threshold crossing height.

- Strategy and decision making
- Crew coordination (monitoring and callouts)
- CFIT awareness (responses)

> Nonprecision approaches may be flown either using the VNAV guidance (Profile Approach Mode) or a conventional manner using Vertical Speed (V/S Approaches). If available, a Profile Approach is highly recommended over a V/S approach due to having VNAV guidance.

The VNAV guidance referred to in the training guide is the VDI, which includes a scale and an indicator[57] that shows the airplane's vertical position relative to the desired glidepath. The VDI appears on the right side of each crewmember's ND. Like the glideslope diamond on an ILS approach, the VDI is the primary source of information about the airplane's vertical position relative to the desired glidepath for a profile mode approach. Consequently, a critical task of the PF and PM when flying a profile mode approach is to constantly scan and monitor the VDI to ensure that the airplane remains centered on the desired glidepath.

When the profile approach is set up properly, the airplane should be navigating along the extended runway centerline toward the threshold, and the sum of the remaining navigation legs should equal the straight-line path over the ground between the airplane and the threshold. When this occurs, the computed height of the desired glidepath will be correct, and the VDI will correctly display any vertical deviations from this glidepath.[58] On the accident flight, however, the first officer, who was the PM, did not set up the profile approach correctly in the FMC because the direct navigation leg to KBHM remained active when it should have been removed. Consequently, the sum of the remaining navigation legs in the FMC was unrealistically long, and the computed height of the desired glidepath was unrealistically high. In addition, a flight plan discontinuity[59] was introduced in the FMC.

One of the steps in properly setting up a profile approach is for the PM to remove unnecessary navigation legs from the FMC to prevent flight plan discontinuities, such as the one that occurred on the accident flight. The navigation waypoints were set up in the FMC as KBHM followed by a flight plan discontinuity, then the COLIG initial approach fix, the BASKN FAF, and the runway threshold. The flight plan discontinuity was built by the FMC when the approach was entered into the FMC to prevent the autopilot from navigating beyond KBHM in the flight plan. Once a flight is no longer navigating via the flight plan in the FMC (that is, when the accident flight received a heading away from the direct-to-KBHM navigational leg to intercept the localizer), UPS guidance recommends clearing the flight plan discontinuity by removing the waypoints that are no longer valid so that the flight plan reflects only the waypoints for the approach to be flown.

[57] This indicator is referred to as the "football" by UPS and is referred to as a diamond throughout this report.

[58] The glidepath constructed by the FMC extends backwards from the runway threshold indefinitely; hence, as long as the airplane is on the extended runway centerline, it does not have to be on an FMC navigation leg for the glidepath height and VDI indications to be correct.

[59] The Airbus FCOM Volume 1, page 1.19.20, defines a discontinuity as a break in the lateral flight plan where two successive path terminations (waypoints/navigation aids) are disconnected.

The improper setup of the flight plan introduced a longer computed distance between the airplane's current position and the runway threshold. While the display was correct based on the geometry that was computed in the FMC as a result of the crew's omissions, it was not an accurate display for the actual position of the airplane relative to the glidepath. This meaningless longer distance, in turn, resulted in a higher altitude from the FMC-generated glidepath compared to what would have been computed had the flight plan been entered correctly. Consequently, from about 0444:17 (when the airplane was about 11.6 nm from the threshold) onward, the VDI was pegged on the upper limit of the scale, indicating that the airplane was well below the FMC-generated glidepath. UPS required the use of the autopilot or flight director and autothrust systems when conducting profile mode approaches. However, because the flight crew did not verify that the flight plan was sequenced, the autopilot could not engage in profile mode.

Activating Final Approach

For the A300 to fly a profile path to a decision altitude, the UPS A300 PTG indicates that the pilot must first select the approach in the CDU and insert the applicable decision altitude/minimum descent altitude (in the case of the BHM LOC 18 approach, this value would be 1,200 ft) into the minimum descent altitude field with the 5 right button, and then line select the 6 right button on the Approach page to activate the approach. In the case of the BHM LOC 18 approach, by selecting the 6 right button, the Approach page title would change from APPROACH to FINAL APPROACH 3.3[60] (see figure 11). The pilot would then push the profile button on the mode control panel to arm the profile mode to intercept the profile path.

[60] The BHM localizer 18 approach called for a 3.28º VNAV [profile] path angle from the BASKN FAF to the threshold crossing height of the runway. The A300 is allowed to fly the VNAV path from within .1º difference between the FMC-generated path angle and the charted path angle.

Figure 11. Photographs of an A300 CDU before and after activating final approach mode.

Vertical deviation (shown as VDEV in figure 11) is displayed on the CDU's APPROACH and PROG pages in digital format and depicted on each ND VDI, where one dot equals 100 ft (200 ft full-scale deflection) (see figure 12). Once final approach mode is activated, the profile path computation changes from performance descent mode to final approach mode.

Figure 12. Photograph of the VDI diamond depicted on the ND display and indicated by a white arrow.

1.7 Meteorological Information

1.7.1 Local Weather Information

The National Weather Service (NWS) Surface Analysis Chart for 0400 on August 14 depicted a stationary front immediately north of the Birmingham area with a weak pressure gradient over the area. The 0247 terminal aerodrome forecast issued by the NWS for BHM was included in the flight crew's flight briefing package. For the time period encompassing the flight's estimated time of arrival, the terminal aerodrome forecast called for variable wind at 3 knots, greater than 6 statute mi visibility, and a ceiling broken at 400 ft agl.

The observations at the time the forecast was prepared indicated that ceilings of 400 ft were occurring at BHM. Other weather reporting locations in the immediate area reported ceilings as low as 200 ft during the period. In the hours leading up to the accident, METAR remarks data showed the ceiling and the variability of the ceiling changing hourly. The normally scheduled BHM meteorological aerodrome report (METAR) at 0353 indicated calm wind, visibility unrestricted at 10 mi, a ceiling broken at 1,000 ft agl, overcast at 7,500 ft, temperature 23° C, dew point 22° C, and altimeter 29.97 in of mercury. Remarks from the observation indicated a variable ceiling from 600 to 1,300 ft agl. After 0400, the BHM automated surface observing system (ASOS) at the airport reported ceilings improving over the airport with a variable ceiling between 700 to 1,100 ft agl.

The aircraft communication addressing and reporting system (ACARS) provided the flight crew with en route updates that showed the ASOS observation and METARs with ceilings broken to overcast at 800 to 1,000 ft. The METAR remarks of variable ceilings of 600 to 1,300 ft were not provided due to specifications by UPS to its weather service provider.

A special weather observation (SPECI) was issued[61] at 0404 and reported calm wind, visibility 10 mi, scattered clouds at 1,000 ft agl, ceiling broken at 7,500 ft, temperature 23° C, dew point 22° C, and an altimeter of 29.96 in of mercury. Variable ceilings were no longer being reported. The SPECI information was not uplinked to the flight crew via ACARS because they did not request it.

The BHM ATIS recordings were manually prepared by the controllers in the BHM air traffic control tower (ATCT). To accomplish this, controllers reviewed METAR information shown on the ASOS display and, along with other information appropriate to an ATIS transmission, manually recorded each ATIS broadcast. The pilots received ATIS information Papa, which was current at the time of the accident, and was prepared based on the 0353 METAR observation; but, it did not include the information from the remarks section about the observed ceiling being variable between 600 and 1,300 ft agl because the air traffic controller did not append the remarks to the broadcast. Although the air traffic controller was aware of the 0404 SPECI, he chose not to update the ATIS, and it retained the lower ceilings observed in the 0353 observation (broken instead of scattered clouds at 1,000 ft).

FAA Order JO7110.65, "Air Traffic Control," paragraph 2-9-3a, states that the following elements should be included in an ATIS broadcast:

> Airport/facility name, phonetic letter code, time of weather sequence (coordinated universal time). Weather information consisting of wind direction and velocity, visibility, obstructions to vision, present weather, sky condition, temperature, dew point, altimeter, a density altitude advisory when appropriate and other pertinent remarks included in the official weather observation.

[61] The SPECI was issued due to a change in the ceiling height over the airport sensors, from a ceiling broken at 1,000 feet agl to scattered clouds.

NWS *Federal Meteorological Handbook No. 1—Surface Weather Observations and Reports* covers the coding of the METAR remarks section and is more specific about what should be included. The handbook indicates that remarks should be included in all reports, if appropriate. Present weather coded in the body of the report may be further described through remarks, noting cloud cover direction from the station or distant weather observed. Movement of clouds or weather may also be coded in the remarks section of the report. Numerous remarks generally elaborate on parameters reported in the main body of the report. These can include peak wind, variable ceiling height, thunderstorm location and movement, beginning and ending of precipitation and thunderstorms, and wind shift or frontal passage and time of occurrence.

FAA Order JO7110.65, paragraph 2-9-2a, requires that ATC make a new ATIS recording upon receipt of any new official weather regardless of whether there is or is not a change in values. Birmingham Tower Standard Operating Procedures, BHM Order 7232.3 J, paragraph 2-2-4J1a, directs that a new ATIS recording be made with the receipt of new official weather regardless of whether a change is involved.

1.7.2 UPS Weather Sources and Information

In 2004, UPS flight control department dispatchers began using the Lufthansa Systems Lido Operations Center flight-planning system[62] to calculate the most efficient route between two points based on weather, wind, terrain, and other factors. When Lido was originally deployed at UPS, the inclusion of the remarks data from the North American METARs was required, along with the weather. In late 2010, the UPS flight control department adopted updated dispatcher workflows regarding use of the Lido in-flight monitoring tool. This tool monitored the weather information coming into the system and provided an alerting mechanism for the dispatcher. After adopting the new workflow, it became apparent that duplicate METAR data streams[63] also resulted in duplicate weather alerts for all potentially relevant airports, which affected dispatcher and pilot workload. In March 2011, the UPS flight control standards group requested that Lido be modified so that the remarks were removed from METAR messages. In response to UPS's request, Lido discontinued sending the remarks data from METARs to populate the flight departure papers and ACARS effective in September 2011.

According to UPS, although the UPS flight control standards group for the dispatchers was aware that the remarks data were no longer provided to the pilots, information regarding the change was not communicated to UPS pilots; further, UPS's director of flight operations told the NTSB that he was unaware that the METAR remarks had been removed. Although UPS pilots could access an online source that included METARs with remarks before departure, pilots would not have access to online sources after departure and would have to directly request such information from the dispatcher.

[62] UPS is currently the only US air carrier using the Lido system, which consolidated multiple applications into a single system. According to the UPS flight-planning support manager, before the Lido flight-planning system, UPS dispatchers had to rely on a variety of other systems and business applications to perform their work planning and flight dispatch.

[63] METAR data streams are obtained from multiple sources through the Weather Message Switching Center. The UPS Lido system used a weather feed from the London World Area Forecast Center and Washington Internet File Service as its source of weather information.

1.8 Aids to Navigation

No problems with any navigational aids were reported.

1.9 Communications

No communications equipment problems related to the accident were reported.

1.10 Airport Information

1.10.1 General Airport Information

BHM is located about 4 mi northeast of Birmingham, Alabama, at a field elevation of 650 ft msl. BHM has two runways: runway 06/24 and runway 18/36. Runway 06/24, the primary runway for air carrier use, was 11,998 ft long and 150 ft wide and was equipped for precision instrument approaches for landing in both directions. However, at the time of the accident, a one-time NOTAM had been issued noting that runway 06/24 was closed between 0400 and 0500 for maintenance of runway edge lights related to an ongoing runway repair and obstruction removal project.[64] Therefore, at the time of the accident, runway 18/36 was the only runway open and in use. Runway 18/36 is 7,099 ft long and 150 ft wide and is equipped for nonprecision localizer approaches and nonprecision RNAV GPS approaches for landing on runway 18, as well as a nonprecision RNAV GPS approach to runway 36, but the approach to runway 36 was not authorized at night.

1.10.2 Precision Approach Path Indicator Information

A four-unit precision approach path indicator (PAPI) system was installed on the left side of runway 18, 1,166 ft beyond the runway threshold.[65] The PAPI for runway 18 was set to project a glidepath of 3.2° to accommodate the rising terrain off the approach end of the runway. The published threshold crossing height was 48 ft.

Ground tests of the PAPI on May 8, 2013, and after the accident on the morning of August 14, 2013, found that the PAPI was adjusted correctly. A postaccident flight check of the PAPI conducted by the FAA on August 16, 2013, indicated that it was functioning properly and within specifications. A postaccident airplane performance study showed that, because the pilots did not report the runway in sight until they were descending through about 900 ft msl (250 ft above airport elevation), the PAPI indications would have been visible for less than 1 second before becoming obscured by rising terrain.

[64] Runway 06/24 was reopened after the accident about 0455.

[65] The PAPI system for runway 18 consists of a row of four light units installed on the side of the runway that provide visual glidepath indications. The on-glidepath angle (typically about 3°) indication is two red and two white lights. Other light combinations indicate when an airplane's position is above the glidepath (four white), slightly above (three white and one red), slightly below (three red and one white), and below (four red). According to the FAA's *Aeronautical Information Manual*, PAPI lights are visible from about 5 mi during the day and up to 20 mi at night.

1.11 Flight Recorders

1.11.1 Cockpit Voice Recorder

The accident airplane was equipped with a solid-state L-3/Fairchild FA2100-1020 CVR designed to record the most recent 2 hours of cockpit audio information. Specifically, it contains a 2-channel recording of the last 2 hours of operation and separately contains a 4-channel recording of the last 30 min of operation.[66] Although the CVR exhibited significant heat and minor structural damage, the circuit boards in the memory module were undamaged, and data were successfully downloaded. The CVR's 2-hour recording contained good quality audio information on both channels; the 30-minute recording contained excellent-to-good quality audio information on three channels.[67] When the recording began, a different flight crew was flying the accident airplane from Benito Juárez International Airport, Mexico City, Mexico, to SDF, where the accident pilots began the flight to BHM. A full transcript was prepared for the accident flight and is provided in appendix B.

1.11.2 Flight Data Recorder

The airplane was equipped with an L-3/Fairchild FA2100 FDR, which recorded flight information in a digital format using solid-state flash memory as the recording medium. Although the FDR exhibited significant heat and minor structural damage, the circuit boards in the memory module were undamaged, and data were successfully downloaded.

The FDR contained about 70.4 hours of data. The accident flight duration was about 46 min. The parameters evaluated were in accordance with the federal FDR carriage requirements, except the recording of the first officer's input control force, which recorded a "no computed data" pattern for the duration of the flight. According to UPS, the failure of this parameter is common in their A300 fleet; the parameter was functional at the airplane's last maintenance check and had not yet been detected by its maintenance program.

1.12 Wreckage and Impact Information

An aerial survey of the airplane's flightpath identified the initial point of impact as a tree strike in a forested area about 6,387 ft north of the runway 18 threshold. Ground scars indicated that the airplane first contacted downsloping terrain in a large gulley about 1,365 ft beyond the initial tree strike. The airplane was destroyed, and the debris field extended down to the bottom of the gulley and up the south side about 2,760 ft south of the initial tree impact.

Two major portions of wreckage were found in the main debris field. The forward fuselage was located about 4,061 ft from the runway 18 threshold on the top of the southern ridge of the gulley and was displaced slightly to the left side of the main debris field as viewed

[66] The fourth channel was configured to record an observer pilot, and, on the accident flight, this channel did not contain any information that was not on the other three channels.

[67] The NTSB uses the following categories to classify the levels of CVR recording quality: excellent, good, fair, poor, and unusable. A good quality recording is one in which most of the flight crew conversations could be accurately and easily understood.

along the intended flightpath to the runway (see figures 13 and 14). The aft fuselage, including the tail section, right wing, and inboard portions of the left wing, were located farther forward, about 3,629 ft from the runway 18 threshold on the downsloping terrain to the runway. The two engines were located within 25 ft of each other about 171 ft west-northwest of the forward fuselage.

Figure 13. Photograph of the left side of the forward fuselage.

Figure 14. Photograph of the right side of the forward fuselage.

Postaccident examination of the wreckage path revealed extensive ground scarring and a distinct fuel odor from the initial ground impact throughout the debris field. Several pieces of left wing structure were embedded in the dirt starting at the initial ground impact. The first evidence of fire began about 4,636 ft from the runway threshold and continued all the way to the aft fuselage section. An extensive postcrash fire consumed most of the aft fuselage of the airplane (see figure 15 for a photograph of the aft fuselage and the right wing wreckage). No evidence of fire was found on the forward fuselage section. The entire airplane was accounted for at the accident site. Postaccident examination of both engines revealed no evidence of uncontainment or preimpact fire.

Figure 15. Photograph of the aft fuselage and the right wing wreckage, with runway 18 in the distance.

1.13 Medical and Pathological Information

Toxicological analyses performed on fluid and tissue specimens from both pilots by the FAA's Civil Aerospace Medical Institute did not detect the presence of carbon monoxide, ethanol, or any of an extensive list of over-the-counter, prescription, and illicit drugs.

1.14 Fire

A postcrash fire occurred, largely affecting the aft fuselage and wings. No evidence of fire was found in or around the forward portion of the fuselage.

1.15 Survival Aspects

Both pilots were fatally injured during the impact sequence. The Jefferson County Coroner/Medical Examiner's Office determined the cause of death for both flight crewmembers was blunt force injuries and provided photographs that showed that, before the pilots were removed from their respective seats, they were wearing their seat restraints, including shoulder harnesses.

1.15.1 Airport Emergency Response

The accident site was about 1.2 mi north of the runway and on property owned by the airport but outside of the airport operations area and beyond the airport perimeter fence. The local air traffic controller activated the crash phone at 0449:22, about 1 min 17 seconds after observing the accident.[68] When interviewed, the local air traffic controller said that the notification call was delayed because he was not immediately able to determine exactly where the airplane had crashed (on or off airport property) and did not know whether to notify ARFF or to call 911 (procedures required that ARFF be contacted on all accidents on or near the airport).

Further, he had difficulty locating the button needed to activate the crash phone circuit on the enhanced terminal voice switch (ETVS)[69] display panel because the system had been reconfigured to accommodate consolidation of the ATCT and terminal radar approach control (TRACON) functions for the midnight shift. The reconfiguration resulted in various selection buttons on the ETVS display appearing in different positions during day and evening operations. The local air traffic controller scrolled through several pages of frequency information before locating the correct button, which was on the first page of the information but in a different location than the daytime configuration. After the accident, the ATCT and TRACON changed their procedures to ensure that the location of the crash phone buttons remained unchanged regardless of facility status or shift.

When the crash phone notification was made, the phones at all four airport emergency response locations rang simultaneously. After the first person picked up the phone, all phones stopped ringing. The firefighter answering the phone at the ARFF station only heard half a ring. When he picked up the phone, the air traffic controller had already begun to describe the nature and location of the emergency. ARFF personnel acknowledged the notification but missed the initial part of the call. Consequently, ARFF personnel did not know that the airplane had crashed and believed that it was still inbound. Due to the miscommunication, when the ARFF units responded about 0453, they initially intended to go to their airport standby positions instead of proceeding to the accident site. After leaving the fire station, ARFF crews contacted the controller to get clearance to enter the movement area and additional information; they were told the nature of the emergency and the location of the accident site. Although emergency response personnel were initially given incomplete information about the accident location, they received corrected information en route to the site and noted that the initial error did not delay their arrival.

After the accident, the BHM airport authority addressed the emergency response issue with all parties and reiterated the correct communications procedures for aircraft accident and incident notification. The airport authority also issued procedures indicating that parties on the crash phone circuit are to answer the crash phone immediately after it stops ringing or after

[68] The BHM ATC facility is an FAA level 8 facility that operates 24 hours a day, 7 days a week, comprising an ATCT and terminal radar approach control (TRACON). At the time of the accident, during the midnight shift ATCT provided TRACON services, which required certain TRACON capabilities to be transferred to the tower. This included radio frequencies on the enhanced terminal voice switch and reconfiguration of the tower radar display.

[69] The BHM ATCT is equipped with an ETVS communications system that provides access to various communications circuits, including the airport crash phone, which is the primary method for immediate notification to the airport's first responders of an accident or incident located on or near the airport. The crash phone circuit connects the ATCT, ARFF station, Air National Guard operations, the Kaiser/Pemco maintenance facility, and the BHM airport authority operations office.

counting to three to ensure that all parties hear the ring, and ARFF has opportunity to join the line as quickly as possible. Additionally, the airport authority has installed a computer-controlled crash phone circuit that will not cause phones at other stations on the circuit to stop ringing if a party on the circuit answers the phone.

1.16 Tests and Research

1.16.1 Flight Simulation

The NTSB conducted simulator testing in an A300 simulator at the UPS training facility on December 4, 2013. During the testing, NTSB investigators entered the accident airplane's decoded flight plan data and the BHM localizer 18 approach into the simulator FMC. The accident flight was simulated from 280 nm north of BHM to the point of impact. The flight plan was consistent with the flight crew navigating directly to KBHM. The localizer 18 approach did not have a feeder route from KBHM; the last waypoint in the active flight plan that the airplane flew while navigating directly to BHM was KBHM. As a result, a F-PLN DISCONTINUITY was created before the first waypoint (COLIG) of the approach and was visible on each of the simulators CDUs (see figure 16). The ND also showed the active routing (directly to KBHM) and the approach routing, as entered in the FMC, with the F-PLN DISCONTINUITY still in the active flight plan (see figure 17).

At the point where the flight crew was directed by ATC to turn right 10˚ and join the localizer, the PM would normally configure the FMC by verifying that the flight plan in the computer reflected only the anticipated waypoints to be flown on the approach, clearing the discontinuity. However, based on the FMC data, this was not done. The flight plan discontinuity remained in the flight plan throughout the flight. In addition, the FINAL APP page on the CDU would have shown a 9,990 value in the vertical deviation field, indicating that it was below the glidepath (see figure 18). According to the UPS A300 check airman, this value is the maximum value able to be displayed.

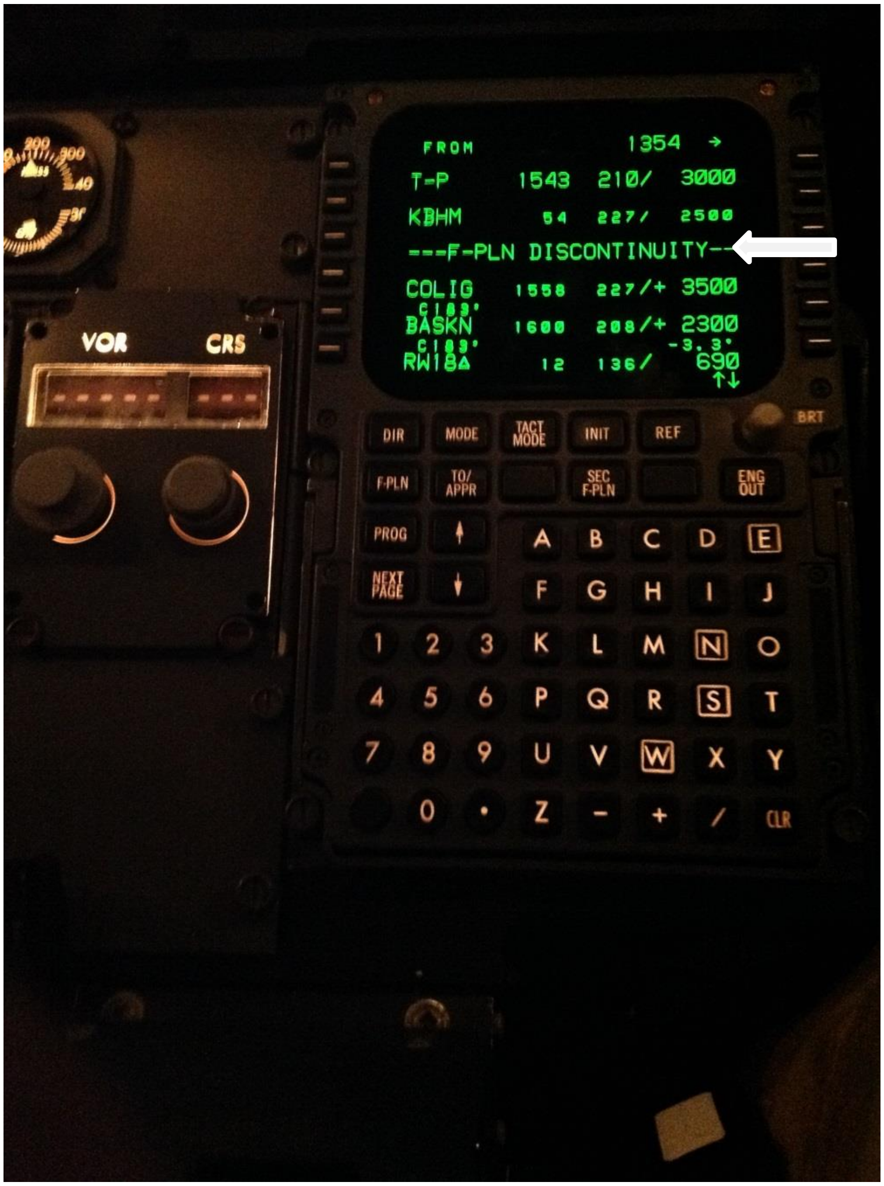


Figure 16. Photograph of the A300 simulator CDU showing the flight plan discontinuity message (indicated by white arrow).

Figure 17. Photograph of the A300 simulator PFD and ND with the flight plan discontinuity (direct to KBHM) in the active flight plan indicated by white arrow.

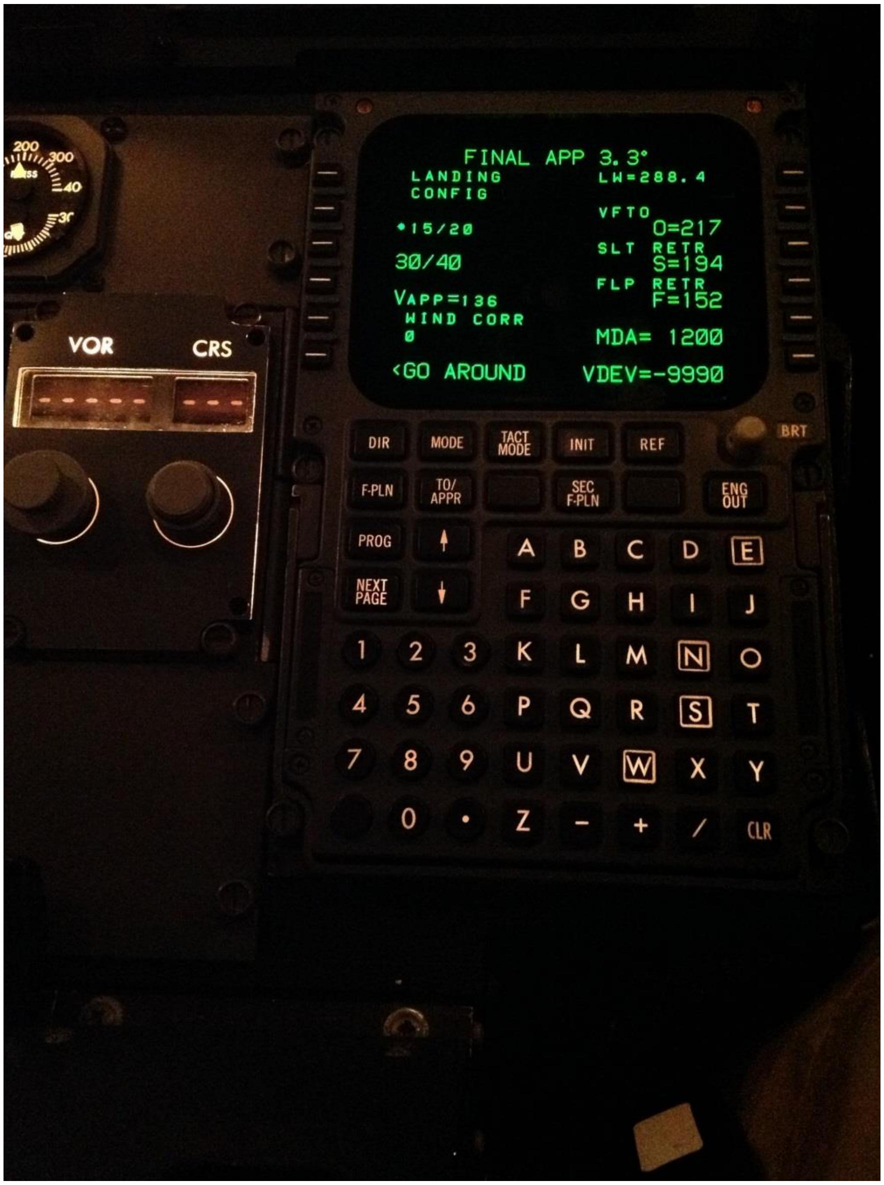


Figure 18. Photograph of the CDU FINAL APP page with the flight plan not verified.

1.16.2 Sequencing the Flight Plan

About 0442, ATC directed the flight crew to “turn ten degrees right, join the localizer, maintain three thousand.” This clearance took the flight off its navigation routing directly to KBHM. According to the UPS A300 PTG, once vectored off of the FMC lateral track, A300 pilots should verify that the flight plan in the FMC reflects the anticipated approach waypoints to be flown, clearing the discontinuity. However, based on the FMC data, this was not done. The

UPS A300 PTG instructed pilots to use an "H.O.V.E." check to properly sequence an approach in the FMC.[70] The UPS A300 PTG, "Initial Approach," states, in part, the following:

> Proper management of the AFDS [autopilot flight director system] significantly enhances the efficiency of the crew when flying any approach. A good "rule-of-thumb" to remember is the "H.O.V.E." check.
>
> (H) = HDG/S - Mode must be used when being radar vectored in the terminal area to comply with ATC instructions.
>
> (O) = Out of Profile - Once vectored off of the FMC lateral track, PROFILE mode is inaccurate and of little use. Therefore, to comply with ATC altitude instructions, the use of LVL/CH [level change] or V/S [vertical speed] modes allows the crew direct control over the vertical path of the aircraft.[71]
>
> (V) = V/N/I switch - Select the V/N/I switch to the appropriate mode for the approach being flown.[72]
>
> (E) = Extend the Centerline - The [PF] should ask the PM to load the expected approach (or runway if accomplishing a visual approach) and extend the centerline. Once the approach has been properly loaded and verified in the FMC, the F-PLN page should reflect the correct sequence of waypoints and altitudes to be flown on the approach. This is also known as sequencing the approach.

During the December 4, 2013, simulator testing, the BHM localizer 18 approach was entered into the FMC; the H.O.V.E. check was then used to verify the flight plan in the FMC. Following the resequencing of the flight plan, the F-PLN DISCONTINUITY could no longer be seen in the active flight plan on the CDU, and the previous navigation path that showed a direct routing to KBHM on the ND was no longer present.

1.17 Organizational and Management Information

1.17.1 General Information

UPS was founded in 1907 as a private messenger and delivery service company in Seattle, Washington. In 1988, UPS received FAA authorization to operate its own airplanes and was certificated under 14 CFR Part 121 as an air carrier.

[70] According to UPS A300 instructors and check airmen, the H.O.V.E. check is to be used by A300 flight crews on all normal approaches (precision and nonprecision); therefore, the check is not unique to nonprecision approaches.

[71] This bullet refers to Profile Performance Descent mode. According to the UPS A300 PTG, the A300 FMC provides two VNAV functions, one used during en route and terminal operations, called Profile Performance Descent mode, and the other to be used during nonprecision approaches, called Profile Final Approach mode. Profile Performance Descent mode computes a geometric path from an altitude constraint backwards to cruise altitude, resulting in an FMC calculated top-of-descent point. This concept is most used when planning a descent from cruise altitude. Profile Final Approach mode computes a geometric path of a fixed angle from a single reference waypoint (usually the threshold crossing height) extending infinitely upward. Profile Final Approach mode is only used to provide vertical guidance during an approach.

[72] The V/N/I switch displays VOR, NAV, or ILS course and deviation information on the ND.

At the time of the accident, UPS corporate headquarters was located in Atlanta, Georgia, and the airline's headquarters was located at SDF. The company employed 331,457 employees, including 2,584 pilots. Records show that, as of December 31, 2012, UPS operated 562 airplanes, which it either owned, operated on capital or short-term leases, or chartered, and had 8 additional airplanes on order.

Title 14 CFR 121.141 requires that the FAA-approved airplane flight manual or an equivalent manual be carried onboard each aircraft. The UPS A300 AOM satisfies the requirement of an equivalent manual, and UPS A300 pilots were required to operate the A300 per the limitations and procedures contained in the AOM. UPS uses the FAA-approved AOM, flight operations manual (FOM), and flight operations training manual (FOTM) as required by 14 CFR 121.135 and 121.403 to provide guidance to flight crews.

The AOM contains the aircraft limitations, normal/abnormal/emergency procedures, supplemental procedures, and performance information. The FOM contains regulations and policies and procedures that pertain to the conduct of flights that are designed primarily for crewmembers and dispatchers and included information from UPS operations specifications (OpSpecs) and other required and appropriate sources. The FOTM provides training guidance. UPS pilots are trained and evaluated on the information contained in the AOM, FOM, and FOTM. Because these manuals are FAA-approved, they are subject to continual FAA review and oversight.

In addition, UPS A300 pilots can reference the guidance contained in the UPS A300 PTG, which outlines UPS policies and recommended techniques to be followed during initial and recurrent training, as well as during line operations. This manual is a reference guide only to assist UPS crewmembers in flying the A300 airplane and to provide a basis for standardization; the UPS A300 PTG is not an FAA-approved or -accepted manual. Information in this manual expands on procedures in the A300 AOM and is intended to illustrate procedures with further, in-depth explanations in how to execute specific maneuvers.

In summary, UPS pilots are required to operate per the limitations and procedures contained in the AOM. In addition, pilots could reference the PTG, which expanded on procedures in the AOM and was intended to illustrate procedures with further, in-depth explanations in how to execute specific maneuvers. UPS also provided information to crewmembers on policies, guidance, and training through its FOM and FOTM.

1.17.2 Stabilized Approach Information

According to the UPS FOM section titled "Stabilized Approach Criteria," all approaches must be stabilized by 1,000 ft above field elevation. At UPS, an approach was considered stabilized when all of the following conditions were met:

- Aircraft is in the landing configuration and the landing checklist has been completed
- Airspeed is within +10 or -5 knots of computed final approach speed
- Sink rate is 1,000 fpm or less and stable

- Aircraft is on a stable vertical path that will result in landing within the touchdown zone
- Engine thrust is stabilized at a level that results in target speed (as listed above)
- Aircraft is aligned with the lateral confines of the runway by 200 ft AFE [above field elevation]
  - Note: *Airspeed must be within 5 knots of target by 500 AFE
  - Note: **Vertical speed up to 1,200 fpm may be acceptable under approach conditions that require higher airspeed/ground speeds due to non-normal aircraft system configuration

The UPS FOM also states the following:

> During an instrument approach, crews are encouraged to stabilize the approach before 1,000 AFE. However, all stabilized approach criteria must be met no later than 1,000 AFE.
>
> Under no circumstances will safety-of-flight be compromised. If at any time during the approach the captain feels that the stabilized approach criteria cannot be achieved or maintained, a go-around must be initiated.

Guidance on stabilized approach criteria is also found in the UPS A300 PTG, which states, in part, the following:

> A good landing begins with a stabilized approach. Stabilized approach requirements are defined in the FOM. All approaches are required to be stabilized no later than 1,000 HAT [height above touchdown], in all flight conditions. Below 1,000 ft HAT only minimum thrust and pitch changes should be necessary to maintain [approach speed] on a normal 3 degree glidepath to the runway, to land in in the touchdown zone. If an approach becomes destabilized below 1,000 HAT a go-around is required.

1.17.3 Pilot Response to EGPWS Alerts

UPS guidance in the A300 AOM section titled "GPWS/EGPWS Alert Procedures" lists the "sink rate" alert as a "caution," requiring a pilot to "adjust pitch attitude and thrust to silence the warning." The AOM also states, in part, the following:

> When any GPWS/EGPWS alert is activated, regardless of its duration, or if a situation is encountered resulting in unacceptable flight towards terrain, take immediate and positive corrective action.

Further, the UPS A300 PTG includes the following EGPWS response guidance:

> If the EGPWS caution alert "Sink Rate, Sink Rate" occurs during a VMC [visual meteorological conditions] approach, the pilot flying must immediately alter the airplane's flight path sufficiently to stop the alert. If the alert continues, or the flight is operating in IMC, the [PF] must perform a go-around or the controlled flight into terrain recovery maneuver, as appropriate. Be advised that using an

excessive rate-of-descent above 1,000 ft agl, such as during a nonprecision approach, can activate an EGPWS alert.

The AOM states that when a "too low terrain" caution alert is activated, the pilot should adjust the flightpath or go around. The PTG advises pilots to perform the aggressive CFIT avoidance maneuver, which involves disengaging the autopilot, rotating the airplane 20º nose up, applying maximum thrust, retracting the speedbrakes, and rotating further, up to stick shaker if required.

1.17.4 Go-Around Policy

UPS's go-around policy is covered in the UPS A300 AOM:

Go-Around Guidance:

- The [PF] may initiate a go-around at any time during an approach.
- Any operating crewmember…shall make a "go-around" callout if an unsafe condition exists or as required by procedure.
- The [PF] response to a go-around callout shall be an immediate go-around/missed approach procedure.

NOTE: The captain retains ultimate responsibility and authority for the safe operation of the flight….Therefore, if the captain determines that the execution of a go-around/missed approach presents a greater risk than continuing the approach, the approach may be continued at the captain's direction.

- If either pilot initiates a go-around/missed approach, it must be flown to its conclusion.

1.17.5 BHM Approach Chart

UPS had tailored its Jeppesen airport information chart for BHM, and UPS pilots were required to review the chart each time they flew into BHM. The chart contained a safety alert (originally requested for inclusion on the airport information chart in October 2005) that stated, in part, the following:

Arrival

- Flight operational quality assurance information indicates a high number of unstable approaches to this airport.
- ATC may keep aircraft at high altitudes before approach.

During the investigation, UPS historical data and archived files were reviewed to determine UPS's basis for adding the safety alert to its BHM airport information chart. No specific information was found, but records showed that, at the time the alert was added, UPS requested multiple safety alert updates to its approach charts. A review of archived data from 2008 to the time of the accident did not reveal any information identifying BHM as a high-risk airport for unstabilized approaches. UPS representatives said that, based on this review, the safety alert should have been removed from the airport information chart; however, the most recent review occurred in 2007 and determined that no changes were needed. Further, a UPS postaccident examination of the BHM airport and pilots' perspectives of the approaches at BHM revealed no information that would identify BHM as high-risk airport for unstabilized approaches.

The Jeppesen 11-2 BHM localizer runway 18 approach chart in effect at the time of the accident had the note "NIGHT: NA" [73] in its minimums section, indicating that the approach was not authorized at night.[74] Therefore, based on the information available to the flight crew on the chart, the localizer runway 18 approach would not have been authorized at the time of the accident.

However, in December 2011, the FAA issued NOTAM 1/3755 (amendment 2A) stating, "Delete note: procedure NA at night. Chart note: When VGSI [visual glideslope indicator] inop [inoperative], procedure NA at night." According to the FAA, NOTAM 1/3755 was cancelled on March 8, 2012, and, although the chart used by the flight crew indicated that amendment 2A had been incorporated, the minimums section of the chart was not changed to reflect the NOTAM. Jeppesen cited "human error" for the omission and on September 13, 2013, reissued the 11-2 BHM localizer runway 18 chart removing the NIGHT: NA restriction in the minimums section.

1.17.6 UPS Crew and Dispatcher Resource Management Policies and Training

1.17.6.1 UPS Crew Resource Management Training

Both the captain's and first officer's most recent CRM training took place during their proficiency training and checks on June 26, 2013. Throughout all aspects of A300 ground and flight training, UPS pilots are trained on the "Big Six" model of CRM: communications and briefings, "what if" planning, time management, teamwork and leadership, automation management, and situational awareness. The ground training includes CRM exercises that require pilots to apply CRM skills and exhibit adequate knowledge of communication processes, crew coordination, situational awareness, and problem solving/decision-making processes. Captain upgrade training includes 2 hours of CRM training focused on applying CRM skills to being an effective captain and includes CRM responsibilities such as leadership, clear communication, good decision-making, situational awareness, and technical proficiency. Training also reviews the consequences of fatigue, including increased vulnerability to mistakes, decreased situational awareness, poor decision-making, overestimation of one's level of ability, and fixation/slowed reaction time.

1.17.6.2 UPS Crew Resource Management Preflight Safety Briefing

Pilots are required to perform a CRM/safety briefing before flight. The UPS FOM states, in part, that "the CRM/Safety briefing serves dual roles: allowing the Captain to set a good CRM

[73] NA indicates not authorized.

[74] The dispatcher reviewed the nonprecision localizer 18 approach at BHM and determined that the approach was not available due to this note in the minimums section.

tone for the flight and allowing complicated procedures to be discussed in detail before engine start when workload and distractions can be minimized."

CRM briefing objectives as outlined in the FOM include the following:

1) Setting a good tone in the cockpit to encourage safe and efficient flight crew coordination;

2) Establishing open lines of communications between all crewmembers, including encouraging the communication of all known threats as soon as they become apparent;

3) Setting the expectation that standard operating procedures [SOP] will be followed;

4) Stimulating good situational awareness and communication when situational awareness has degraded

5) Rejected takeoff procedures and philosophy (include any safety-related issues which may affect the decision to reject such as weather, MEL [minimum equipment list] deferrals, windshear etc.)

During postaccident interviews, the FAA aircrew program manager and UPS crewmembers indicated that a check item for fatigue was not included in a briefing before takeoff.

1.17.6.3 UPS Crew Resource Management Steering Committee

UPS has a CRM steering committee composed of management and line pilots from each airplane model fleet. At the time of the accident, the committee met quarterly to review CRM issues and recommend any changes to CRM training to the director of training and standards. The committee focused primarily on the threat-and-error management model, which committee members reinforced through training, facilitated debriefs between pilots and their instructors, and encouraged pilots to use threat error management during operations as much as possible. In 2013, the committee developed a training character called "Max Threat," who represented various hazards to pilots while in the cockpit. Its purpose was to instruct pilots how to use CRM principles and techniques to rid themselves of "Max Threat." The committee produced several videos featuring the character that were included in UPS CRM training.

1.17.6.4 UPS Dispatcher Resource Management Training and Policies

Much like pilots are taught CRM principles and techniques, UPS dispatchers are taught dispatcher resource management (DRM).[75] As outlined in the UPS FOTM, one of the objectives of DRM is to teach dispatchers how to "better interface with each [pilot-in-command], consistent with the joint responsibility concept" outlined in 14 CFR 121.533, "Responsibility for

[75] Flight dispatchers are required to be trained under the provisions of 14 CFR 121.415, "Crewmember and Dispatcher Training Requirements" and 14 CFR 121.422, "Aircraft Dispatchers: Initial and Transition Ground Training."

Operational Control. Domestic Operations."[76] This objective is also mentioned as a benefit in FAA AC 121-32A, "Dispatch Resource Management Training" (issued November 21, 2005), which provides guidance to operators for developing, implementing, reinforcing, and assessing DRM training programs for aircraft dispatchers. The AC states that a second expected benefit of DRM training for aircraft dispatchers is "better management of information that has a direct impact on safe flight operations." According to the AC, a goal of DRM training is to "address the challenge of optimizing communication between diverse groups within an airline and the related interpersonal issues while using available resources." Further, the AC advises operators that DRM should include all operational personnel (including pilots) to improve teamwork.

The UPS FOTM outlines the training curriculum for the company's dispatchers. According to a UPS flight control shift manager, after initial training, general subjects and all classroom instruction, dispatchers undergo specific on-the-job training, including performance problems, looking at MEL problems, and explaining what they would do and how they would apply penalties and restrictions. They are required to spend a specific number of days on the desk, as well as take a written practical and oral examination, each of which is 9 hours long.

Flight dispatchers are also required to receive recurrent training to the requirements specified in 14 CFR 121.427 (a)(b)(c) and 14 CFR 121.463(c). The course must provide refresher training in those subjects and procedures as required by 14 CFR 121.422(a) and 14 CFR 121.629. Recurrent dispatcher training is required every 12 months, and the UPS dispatcher initial and recurrent training curriculums are outlined in the UPS FOTM. According to the UPS flight control shift manager, dispatchers have 1-day recurrent training in the fall and spring. Dispatchers are also required to receive an annual competency check.

According to UPS, dispatchers receive about 18 hours of total training each year, including 1 hour of DRM training. However, dispatchers and pilots, who share equal responsibility for the safety of a flight as noted in the UPS FOTM and FAA AC 121-32A, did not train together. UPS does not require its pilots and dispatchers to communicate directly during normal dispatch operations or have a verbal dispatch briefing before every flight. However, a UPS flight control shift manager said that UPS dispatchers had multiple means to interact with a flight crew, including cell phone or landline phone, satellite communications, the Aircom Server[77] on most airplanes, or the ACARS.

The accident dispatcher stated that he was not required to and generally did not talk with pilots. He indicated that he typically only spoke with pilots when they initiated the conversation, usually when they discovered a MEL item that was not listed on the flight plan during the initial boarding process, if there was something new on the airplane, or if there was significant weather en route or at the destination. According to UPS, a dispatcher would be required to inform the pilots of an issue under some circumstances. For example, a UPS manager indicated that the dispatcher would be required[78] to inform the pilots if an approach was unauthorized for the

[76] During the NTSB's February 20, 2014, investigative hearing for this accident, the UPS flight control manager testified that "better interface" meant "contact with the [pilot-in-command]." He indicated that the interface included talking with the pilot on the phone or the ACARS system.

[77] The Aircom Server provides air-to-ground communications management.

[78] Title 14 CFR 121.601(a) states, "The aircraft dispatcher shall provide the pilot in command all available current reports or information on airport conditions and irregularities of navigation facilities that may affect the safety of the flight."

approach runway. However, during postaccident interviews, the accident dispatcher stated that he did not want to "insult" the captain by informing him of what the dispatcher viewed as an unavailable approach to the runway 18.[79]

The accident dispatcher reported that his typical workload in a shift involved planning 20 flights on the domestic side and flight-watching 10 flights.[80] He said that, for international flights, his workload was about 10 to 15 flights because of the difficulty involved. On the night of the accident, he had planned 20 flights and flight-watched 10 to 15 flights. At the time of the accident, he was working the accident flight, and all of his other watch flights had already landed.

1.17.7 Pilot Flight and Duty Time

The accident flight was operating under the provisions of 14 CFR Part 121 Subpart Q (at 14 CFR 121.471[a]), which lists the flight-time limitations and rest requirements for domestic operations as follows:

> (a) No certificated holder conducting domestic operations may schedule any flight crewmember and no flight crewmember may accept an assignment for flight time in scheduled air transportation or in other commercial flying if that crewmember's total flight time in all commercial flying will exceed—
>
> (1) 1,000 hours in any calendar year;
> (2) 100 hours in any calendar month;
> (3) 30 hours in any 7 consecutive days;
> (4) 8 hours between required rest periods.

The UPS contract with the Independent Pilots Association (IPA) provides additional limitations on flight and duty times and rest requirements for flight operations during an early duty window, which is defined as between 0230 and 0459 local domicile time. Any operation that reported in, blocked in, or overlapped with the early duty window is considered an early duty window period. The UPS/IPA contract limits a crewmember flying a domestic early duty window from being scheduled a duty period that exceeded 11 hours on duty or being on actual duty for more than 13 hours. The 13 hours may be extended to 14 hours only if a flight was delayed due to weather, mechanical, or ATC delays. The contract further states that early duty window operations cannot exceed four segments in a scheduled duty period and that a crewmember cannot be scheduled more than four consecutive duty periods that contain four early duty window segments.

After completing an early duty window period, a crewmember should receive 10.5 duty-free hours of layover rest. If an early duty window period is scheduled for 10.5 hours or more, or contains four segments, the crewmember should receive 12 duty-free hours of

[79] As noted previously, due to an error on the BHM chart, the dispatcher believed that the runway 18 localizer approach was not available.

[80] Watching flights is another term for flight-following. Dispatchers are responsible for a flight from planning until safe completion. They either follow their own flights or those from a dispatcher who they have relieved.

layover rest. The 12-hour rest period may be reduced to 10.5 hours in the event of weather, mechanical, sort, or ATC delays.

1.17.8 UPS Fatigue Policies, Guidance, and Training

1.17.8.1 Fitness for Duty Policy and Guidance

The UPS FOM introduction regarding crewmember fitness for duty states the following:

> UPS crewmembers are expected to report for all assignments fit for duty. Further, UPS crewmembers are prohibited from operating aircraft if they are not fit for duty. Fitness for duty is defined as being physiologically and mentally prepared and capable of performing assigned duties.
>
> Crewmembers must notify Crew Scheduling immediately if they are not fit for duty for any reason.
>
> This decision is vital to safety and the notification must occur without hesitation. Crew Scheduling will remove the crewmember from service and provide further assistance, as required.
>
> Fitness for duty includes, but may not be limited to, being free from illness, injury, fatigue, scuba diving restrictions, blood donations, alcohol, drugs, etc.

The UPS FOM addressed fatigue as follows:

> Do not operate as a crewmember if fatigue compromises your ability to safely perform your assigned duties. Crewmembers are expected to report for duty rested and prepared for scheduled duty periods. Duty periods may include revision or reschedule as defined by the Collective Bargaining Agreement.
>
> NOTE: In addition to notifying Crew Scheduling, crewmembers who determine they cannot perform assigned duties due to fatigue, are required to complete a Fatigue Event Report.

1.17.8.2 Fatigue Risk Management

The UPS fatigue risk management plan (FRMP) is outlined in the UPS FOM chapter on CRM and states the following:

> Fatigue risk management is a continuous improvement process that identifies, assesses and mitigates the risk of fatigue by guiding organizational and/or policy change and fatigue risk management promotion through training and communication.
>
> A comprehensive UPS fatigue risk management plan collects and analyzes fatigue data to proactively manage fatigue threats and ensures unacceptable risks are mitigated. Fatigue training is incorporated into annual training for all crewmembers, crew schedulers/crew resource personnel, dispatchers and

operational decision-makers. The UPS FRMP has been approved by the FAA. The FRMP scheduling limits are representative of the UPS/IPA Collective Bargaining Agreement.

The global, 24-hour nature of operations, including backside-of-the-clock flying, flights crossing multiple time zones, and the range associated with modern aircraft can create challenges for air carriers and pilots in managing rest. Therefore, it is imperative that UPS Flight Operations personnel proactively manage alertness and mitigate fatigue.

1.17.8.3 Flight Crew Alertness Guide

The UPS fatigue safety action group,[81] which is responsible for UPS fatigue education, developed the Flight Crew Alertness Guide provided to crewmembers in the FOM. The guidance contains practical tips for obtaining adequate sleep, recovering from a sleep debt, and identifying sleep problems/disorders when at home and away. The alertness guide was developed in conjunction with an outside consultant and provided to the IPA to review before publication.

1.17.8.4 Fatigue Training

UPS presents its pilots with fatigue training during initial CRM training and subsequently in the one-time CRM flight crew factors seminar. According to the FOTM, the fatigue curriculum segment covers the following areas:

1) Review of FAA flight, duty, and rest regulatory requirements.

2) Awareness of the FRMP program itself, including fatigue-related policies and procedures, and the responsibilities of management and employees to mitigate or manage the effects of fatigue and improve flight crewmember flight deck alertness.

3) The basics of fatigue, including sleep fundamentals and circadian rhythms.

4) The causes and awareness of fatigue.

5) The effects of operating through multiple time zones.

6) The effects of fatigue relative to pilot performance.

7) Fatigue countermeasures, prevention, and mitigation.

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[81] The fatigue safety action group includes a safety manager and a data analyst from the company's safety department, two members from the chief pilot's office, one member from the crew scheduling department planning office, one member from the industrial engineering department, a flight operations compliance manager, and a flight-qualified supervisor. The group is responsible for a fatigue review and the development of education at UPS and the Flight Crew Alertness Guide. In addition, the fatigue safety action group reviews deidentified information for each fatigue event and performs a root cause analysis.

8) The influence of lifestyle, including nutrition, exercise, and family life, on fatigue.

9) Familiarity with sleep disorders.

10) The effects of fatigue as a result of commuting.

11) Pilot responsibility for ensuring adequate rest and fitness for duty.

12) Operational procedures to follow when one identifies, or suspects, fatigue risk in oneself or others.

13) Lessons learned regarding the effects of fatigue and mitigation initiatives relative to the certificate holder's operations.

UPS also presented fatigue causes and countermeasures training during its annual advanced qualification program and continuing qualification training in either forum or home study format, as outlined in the advanced qualification program manual. The 2013 continuing qualification home study document's review of fatigue addressed the UPS FRMP, safety culture, and joint responsibility between the company and crewmembers to ensure fitness for duty. The first officer completed the training on June 5, 2013, and the captain completed it on June 6, 2013. The document provided additional guidance, which stated the following:

> It cannot be overstated that sleep or lack of sleep greatly affects our level of performance. Sleep is a resource that must be managed. Managing our sleep is imperative if we are to maximize our ability to handle both routine flying tasks and possible emergency situations. Sleep deprivation is cumulative and diminishes your ability to operate safely. It is each crewmember's responsibility to assure that they manage their duty free periods so as to report to work fully rested.
>
> Because UPS operates worldwide in all time-zones it can be a challenge to properly manage your rest. Your ability to communicate to other crewmembers and the company on the status of your readiness to fly is important in evaluating your ability to function as a viable crewmember. Proper exercise and eating habits also help minimize the effects of fatigue. Studies show that moderate exercise completed several hours before bedtime can help in assuring restful sleep. Also, before bedtime avoid large or heavy meals and alcohol, which have been found to interfere with sound sleep.

1.17.8.5 Fatigue Event Reporting and Review

If a UPS pilot reports a fatigue event that requires removal from duty, related information is reviewed at least twice: first by the UPS flight compliance supervisor then by the scheduling supervisor. The two supervisors meet once a week to review fatigue calls and decide whether to debit the pilot's sick bank for the fatigue call.[82] Final determination about sick bank debits is

[82] The pilot's sick bank would be debited for the time not flown if it was determined that the pilot was responsible for being fatigued (for example, if the pilot mismanaged off-duty time).

made by the UPS fatigue working group, which consists of personnel from UPS (such as the flight compliance supervisor who is co-chair of the working group) and IPA. In addition to reviewing fatigue events, the working group also reviews pilots' submitted schedule complaints and schedule trends for the month.

If the UPS fatigue working group cannot agree on whether to debit a pilot's sick bank, the event is elevated to the IPA president and the system chief pilot for review. If no determination can be agreed upon by the IPA president and system chief pilot, UPS can debit the pilot's sick bank in accordance with the memorandum of understanding between IPA and UPS. Every fatigue call is subsequently deidentified for root cause analysis and identification of any corrective action by the fatigue safety action group.

According to the UPS fatigue working group, most of its pilots' fatigue calls resulted in no reschedules or major delays. Of the 13 pilots interviewed during this investigation, 6 said that they had called in fatigued 4 of these said they would feel comfortable calling in fatigued again. One pilot had called in fatigued three times. He said that he was thoroughly questioned after the second occasion and that his sick bank was debited on the third occasion. He said he was now concerned about future responses if he called in fatigued. Another pilot indicated there were no negative consequences when he called in fatigued. A review of UPS records from 2011 to the day of the accident found no fatigue event reports filed by either the captain or the first officer during that time.

1.18 Additional Information

1.18.1 Postaccident Safety Actions

Following the accident, the BHM airport authority and BHM control tower replaced the emergency phone system and updated procedures so that the appropriate emergency response parties are notified in a timely manner. The BHM control tower management also provided refresher training to controllers on entering remarks data and updating ATIS reports.

1.18.2 FAA Regulations and Guidance

1.18.2.1 Flight- and Duty-Time Regulations

On January 4, 2012, the FAA published the final rule for 14 CFR Part 117, which prescribed new flight- and duty-time regulations for all flight crewmembers and certificate holders conducting passenger operations under Part 121. The final rule became effective on January 4, 2014, about 4 1/2 months after the accident. All-cargo operators were not required to implement the provisions of Part 117 although they could voluntarily comply with the new requirements. Table 2 compares the Part 121 and 117 flight- and duty-time requirements, the UPS early duty window operations policy, and the accident pilots' duty periods before the accident.

Table 2. Comparison of FAA duty-time regulations with the accident flight crew's duty periods before the accident.

	Part 121[a]	Part 117[b]	UPS early duty window operations	Accident flight crew's schedule[c]
Maximum duty time	N/A	11 hours	11 hours	8 hours 11 minutes
Maximum flight hours	8 hours	8 hours	8 hours	2 hours 29 minutes
Minimum rest requirement	9 hours	10 hours	10.5 hours	14 hours 28 minutes
Maximum consecutive nights	N/A	5 nights[d]	4 nights	2 nights

a. Minimum rest requirements under 14 CFR Part 121 Subpart Q are based on the number of flight hours scheduled in 24 consecutive hours.

b. Maximum duty time under 14 CFR Part 117 is based on scheduled start time and number of flight segements. Maximum flight hours is based on scheduled start time. The data presented are based on the flight crew's schedule the day of the accident. See Exhibit 14-G Excerpts – 14 CFR Part 117 in the public docket for more information.

c. These are the actual times based on the accident flight crew's schedule.

d. Title 14 CFR Part 117 limits consecutive nights to three if there is no opportunity to obtain 2 hours of rest in a suitable location during the flight-duty period.

The NTSB asked the FAA to review the accident flight crewmembers' schedules to determine if the schedules would comply with the limitations prescribed in Part 117 (even though these rules were not in effect at the time of the accident and do not apply to all-cargo operations). The NTSB provided the FAA with the accident crew's schedules for the 60 days before the accident and the trip pairing that included the accident flight.[83] The FAA concluded that "on June 29, 2013, [the accident captain] had a scheduled rest period of 9 hours and 56 minutes and his actual rest period was 9 hours and 51 minutes. Part 117 would have required 10 hours rest as measured from the release of all duty (§ 117.25(e)). The 10-hour rest period must have provided a minimum of 8 uninterrupted hours of sleep opportunity." Also, from July 16 through 21, 2013, and again from July 30 through August 4, 2013, the accident captain "was scheduled for six (6) consecutive nighttime duty periods. Part 117 would have limited [the accident captain] to a maximum of five (5) consecutive nighttime flight duty periods (FDPs) provided each of the five FDPs provided a minimum of 2 hours rest in a suitable accommodation (§ 117.27). Otherwise, he would have been limited to three (3) consecutive nighttime FDPs." Lastly, the FAA concluded that for the captain, "no [P]art 117 cumulative FDP or flight time limitations would have been exceeded." The FAA also concluded that for the first officer's schedule "no prescribed limitations in [P]art 117 would have been exceeded."

1.18.3 Data Related to Unstabilized Nonprecision Approaches

A review of the National Aeronautics and Space Administration's (NASA) aviation safety reporting system (ASRS) reports[84] showed 62 reports at 17 airports related to nonprecision

[83] For the captain, the pairing began 1 day before the accident and for the first officer, it began 4 days before the accident.

[84] According to NASA ASRS, "ASRS reports referencing safety incidents are considered soft data. The reports are submitted voluntarily and are subject to self-reporting biases. Such incidents, in many cases, have not been corroborated by the FAA or NTSB. The existence in the ASRS database of records concerning a specific topic cannot, therefore, be used to infer the prevalence of that problem within the National Airspace System. Reports submitted to ASRS may be amplified by contact with the individual who submitted them, but the information provided by the reporter is not investigated further. At best, it represents the perception of a specific individual involved in or witnessing a given issue or event."

approaches involving Part 121 operations. Nine reports were most closely related to the UPS flight 1354 accident. In four events,[85] the crew descended below an altitude constraint, and in three events,[86] the crew received an EGPWS terrain alert. In another event,[87] a crewmember indicated "inadequate and poorly administered training on VNAV/autoflight nonprecision approach procedures." In the last event,[88] a dispatcher reported a "communication breakdown between himself and the flight crew" regarding the approach that was going to be flown to the runway. He further stated that he "had several Captains in the past who were interpreting approaches, charts and regulations incorrectly."

Industry analysis of data for operations across the National Airspace System indicates that most flights comply with commonly accepted industry standards for stable approach. A similar industry analysis was applied to operations at a subset of 31 airports that have at least one runway without an ILS,[89] a situation more similar to that of the accident flight, which was on approach to a runway without an ILS.[90] Approaches to runways with and without an ILS[91] at 31 airports were compared with respect to vertical speed metrics. The vertical speed of flights on approach to runways with an ILS at these airports exceeded a vertical speed of 1,450 fpm[92] at 1/3 of the rate of approaches to runways without an ILS.

A TAWS alert indicates a heightened risk of flight into terrain and is not expected during a stable approach, especially when vertical guidance is available. Industry analysis of data for operations across the national airspace system indicates that TAWS alerts are very rare, occurring in fewer than 1 in 10,000 approaches. Additionally, in the analysis of 31 airports that have at least one runway without an ILS, the rate of TAWS alerts[93] was compared for runways with and without an ILS with the following findings:

- The rate of Mode 2 alerts[94] for approaches to runways with an ILS was 1/10 of the rate of Mode 2 alerts for approaches to runways without an ILS.
- The rate of EGPWS alerts for approaches to runways with an ILS was 1/3 of the rate of EGPWS alerts for approaches to runways without an ILS.

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[85] See ASRS report numbers 1133632, 932134, 1010118, and 722952, which can be accessed at http://asrs.arc.nasa.gov/.

[86] See ASRS report numbers 824453, 732267, and 605041, which can be accessed at http://asrs.arc.nasa.gov/.

[87] See ASRS report number 955740, which can be accessed at http://asrs.arc.nasa.gov/.

[88] See ASRS report number 987675, which can be accessed at http://asrs.arc.nasa.gov/.

[89] The dataset included approximately 1.4 million approaches for commercial airline operations over the past 3 years.

[90] Since many of the nonILS runways have rising terrain near the airport, terrain alerts would be expected to occur more often than in the national airspace system overall. Rising terrain features can prohibit installation of an ILS.

[91] The analysis distinguishes between approaches to runways with and without an ILS, but cannot be used to infer the type of approach that was flown. The results are indicators of the effect of ILS vertical guidance availability, not evidence of use.

[92] Below 500 ft height above touchdown.

[93] Two types of TAWS alerts were measured in industry data: Mode 2 (Terrain) alert, a GPWS Pull Up Warning preceded by a GPWS Terrain Caution; EGPWS alert, a Terrain Awareness Warning preceded by Terrain Awareness Caution.

[94] The analysis does not distinguish between versions of TAWS software or GPS-enabled TAWS.

2. Analysis

2.1 General

The pilots were properly certificated, qualified, and trained for the 14 CFR Part 121 flight in accordance with FAA regulations. No evidence was found indicating that the flight crew's performance was affected by any behavioral or medical condition or by alcohol or drugs.

The accident airplane was loaded within weight and center of gravity limits and was equipped, certificated, and maintained in accordance with FAA regulations and the manufacturer's recommended maintenance program. Postaccident examination found no evidence of any preimpact structural, engine, or system failure or anomaly.

The air traffic controller activated the airport crash phone 1 min 17 seconds after the accident. The controller was uncertain of the exact location of the accident and did not know whether to notify ARFF or call 911 (procedures required that ARFF be contacted on all accidents on or near the airport). Additionally, due to an equipment reconfiguration, the call was delayed because the controller was not able to locate the button needed to activate the crash phone circuit on the ETVS display panel in a timely manner. The NTSB concludes that, although the activation of the crash phone was delayed, the ARFF response proceeded rapidly, and ARFF operations began in a timely manner.

This analysis discusses the predeparture planning, the accident sequence, the flight crew's performance, and operational and systems issues.

2.2 Predeparture Planning

A NOTAM had been issued closing the longest runway at BHM, 06/24, which was equipped with an ILS precision approach, from 0400 to 0500 on the morning of the accident. This closure left only the shorter runway, 18/36, available for the UPS flight 1354 landing, which was scheduled for 0451. The dispatcher was aware of the NOTAM closure for runway 06/24 when he was flight-planning and included the NOTAM in the flight release paperwork; however, he did not bring the NOTAM to the flight crew's attention. The flight crewmembers' preflight review should have cued them to consider the limited approach options available to the remaining runway; however, the investigation could not confirm whether the flight crewmembers became aware of the NOTAM during their paperwork review.

Because of the closure, the dispatcher planned for UPS flight 1354 to land on runway 18. He reviewed the Jeppesen approach chart at BHM and determined that the nonprecision localizer runway 18 approach was not available due to a note in the minimums section of the chart stating the approach was not authorized at night.[95] Thus, from the

[95] As noted previously, although this NOTAM was cancelled on March 8, 2012, and the Jeppesen 11-2 BHM localizer 18 chart used by the dispatcher and flight crew indicated that an amended NOTAM was incorporated, the minimums section of the chart was never changed to reflect the amended NOTAM. Jeppesen reissued the 11-2 BHM localizer 18 chart on September 13, 2013, removing the NIGHT: NA restriction in the minimums section of the chart.

dispatcher's perspective, the only available approach to runway 18 for the flight was the RNAV approach. At the time the flight was dispatched, the forecast cloud ceiling at BHM about the time of arrival was below the minimum descent altitude for the RNAV 18 approach. As a result, there was a strong possibility that the flight would have to hold or divert to its alternate in Atlanta, Georgia, if the RNAV approach was used.

The accident flight dispatcher did not notify the captain about the runway restrictions because, as he reported to the NTSB, he did not want to "insult" the captain by informing him of what he viewed as an unavailable approach to the shorter runway 18. Although the flight crew should have known about the limited options for arrival at BHM and could have initiated communication with the dispatcher, the dispatcher should have ensured that the pilots were aware of this information.

The CVR recorded the pilots performing normal preflight checklists and checks and a conversation about recent changes to cockpit flight- and duty-time regulations. During a typical preflight, the captain should have verified the available approaches to the runways, the runway closure window, and forecast ceilings below nonprecision approach minimums; he should have also considered delaying his arrival into BHM to allow for the ILS approach to the longer runway. Although no discussion of these areas was recorded on the CVR, the flight crew may have discussed them at an earlier time. The NTSB concludes that the dispatcher of UPS flight 1354 should have alerted the flight crew to the limited options for arrival at BHM, especially that runway 18 was the only available runway, because doing so would have further helped the pilots prepare for the approach to BHM and evaluate all available options. See section 2.5.1 for a discussion about DRM training.

2.3 Accident Sequence

2.3.1 Approach to BHM

After departing SDF, the flight crew navigated using the FMC direct to KBHM. At 0421:28, after listening to the BHM ATIS Papa mentioning the 06/24 runway closure, the first officer said, "they're sayin' six and two-four is closed. They're doin' the localizer to one eight," and the captain responded, "localizer (to) one eight, it figures." Based on these comments, it is likely that the flight crew did not realize before departure that runway 06/24 would be closed at the time of arrival.

At 0433:33, the approach controller cleared the flight to descend to 11,000 ft msl, and the captain commented, "They're generous today. Usually they kind'a take you to fifteen and they hold you up high," indicating that, although the captain may have been kept at a higher altitude in the past, he was given a lower altitude on this leg. At 0441:44, the first officer requested a lower altitude, and the controller cleared the flight to descend to 3,000 ft msl.

At 0442:05, the controller vectored the flight 10º right to join the localizer and to maintain 3,000 ft. According to UPS guidance, once vectored off of the FMC lateral track, the first officer, as PM and at the direction of the PF, should have used the CDU to clear the previous navigation routing and flight plan discontinuity and to sequence the FMC so that it only reflected the anticipated approach waypoints to be flown. However, postaccident review of downloaded FMC data indicated that, although the first officer activated the approach, she did not verify the flight plan was sequenced for the approach. Additionally, the captain did not call for the first officer to verify the flight plan. These omissions resulted in the FMC generating meaningless vertical guidance to the runway. See section 2.6.3 for more information on sequencing of the FMC.

Several cues could have led the flight crew to believe the approach was set up properly, such as (1) the localizer was captured, (2) the airplane icon was positioned on the localizer on the ND, and (3) the first officer was able to activate the approach to runway 18 in the FMC. Further, the PFD and ND did not provide a specific indication that the approach had not been properly sequenced.[96] Nonetheless, multiple cues on the NDs could have alerted the pilots that the flight plan was not verified. Specifically, (1) the lateral flight plan displayed on the ND had an unusual line shape due to the discontinuity with the next approach fix to be flown, (2) the VDI was pegged to the upper scale as the airplane approached the FMC-generated glidepath capture area near BASKN and "-9999 ft" was displayed on the CDU page, (3) instead of showing the course and distance to the BASKN FAF on the ND, the course and distance to KBHM would have been shown; (4) the lateral course deviation displayed on the ND would not have been counting down to zero appropriately when the airplane intercepted the localizer; (5) once the approach was activated by the first officer, the VDI would have appeared with a full-scale deflection up, indicating that the airplane was significantly below the glidepath, even though the airplane was above the glidepath, which the flight crew was aware of, and (6) there was a major discrepancy between distance to destination and distance to runway on the CDU progress page.

However, the flight crewmembers did not detect these cues. They were engaged in a conversation about the localizer 18 approach option to the runway and their concern that ATC had left them high on the approach. Although this conversation involved operational issues, it focused on past activities and would have been a distraction to the flight crew's focus on the present and future actions necessary to successfully complete the remainder of the flight. The cues associated with the flight crew's failure to verify the flight plan would have been especially salient as the airplane aligned with the localizer, and the flight crew's discussion came at an inopportune time. The NTSB concludes that the captain, as PF, should have called for the first officer's verification of the flight plan in the FMC, and the first officer, as PM, should have verified the flight plan in the FMC; their conversation regarding nonpertinent operational issues distracted them from recognizing that the FMC was not resequenced even though several salient cues were available.

2.3.2 Vertical Deviation and Continuation of the Approach

2.3.2.1 Failure to Capture the Glidepath

At 0443:24, the approach controller cleared the flight for the approach stating, "maintain two thousand five hundred till established on localizer, cleared localizer one eight approach." The airplane was 11 mi from the BASKN FAF at this time. According to radar and CVR data, the airplane became established on the localizer when it descended through 3,800 ft and, consistent with the minimum altitude for that segment of the approach, could have descended to

[96] A specific indication that the approach had not been properly sequenced was the F-PLN DISCONTINUITY message on the FMC F-PLN page if the first page of the flight plan was selected in the FMC.

the FAF minimum crossing altitude of 2,300 ft when inside of COLIG. However, the captain did not do so, and he maintained 2,500 ft.

The UPS A300 AOM and PTG recommended descending to the FAF crossing altitude before intercepting the profile glidepath on nonprecision approaches because intercepting the profile glidepath outside the FAF did not guarantee step-down fix compliance for those fixes that occur before the FAF. Although the flight crew repeatedly commented about being high on the approach, they did not discuss descending to 2,300 ft after they became established on the localizer between COLIG and BASKN. Additionally, it is important to note that, at this stage in the approach and well before the FAF of BASKN, the airplane was only 200 ft above the minimum altitude, which could have been corrected with minimal effort.

For the autopilot to capture the profile glidepath, the autopilot profile mode must be armed by pushing the profile button, and the flight plan must be verified in the FMC. Because the flight plan had not been properly sequenced in the FMC and the autopilot profile mode may not have been armed,[97] the autopilot was unable to capture the profile glidepath as the airplane approached it, and the airplane never began a descent on the 3.28° profile glidepath to runway 18.

As the airplane neared the BASKN FAF, the controller cleared the pilots to land on runway 18, and the first officer performed the Before Landing checklist. During this time, the captain likely perceived that the autopilot did not capture the profile glidepath and chose to change the autopilot from profile mode to vertical speed mode to manually command a descent to the minimum descent altitude of 1,200 ft msl. This change in method of descent occurred before the FAF and was not consistent with the originally briefed approach plan, but the captain did not communicate this change to the first officer. Although the flight crew may have thought that they were kept high during the approach into BHM, if the captain thought that they were too high, or higher than he was comfortable with, he was responsible for mitigating the perceived risk by discontinuing the approach.

At 0446:25, about 10 seconds after completing the Before Landing checklist, the first officer queried the captain about the airplane's descent, stating, "let's see you're in…vertical speed…okay," and the captain responded "…yeah I'm gonna do vertical speed, yeah he kept us high." The captain initially set the descent rate at 700 fpm and 17 seconds later changed it to 1,000 fpm. Then, 14 seconds later, the captain then increased it to 1,500 fpm. At 0446:54, the captain commented, "and we're like way high," to which the first officer responded, "about...a couple hundred ft...yeah."

With limited time and altitude available on the approach, the first officer's workload was further increased because she had to mentally process the change from the profile approach to vertical speed approach method. Additionally, the pace of her PM duties would have further increased her workload because the 1,500 fpm descent rate was about twice as fast as the normal

[97] Downloaded FMC data indicated the profile path was not armed at impact (either the profile button was never pushed to arm the profile descent, or the profile button was pushed twice, first arming the profile path then again, disarming it). Normally, the profile mode is armed by pushing the profile button on the mode control panel and is indicated on the flight mode annunciator with a blue P. DES light indication. Capture of the profile descent path would be indicated on the flight mode annunciator with an initial flashing of the blue P.DES, then a steady green P.DES indicating path capture. The first officer's comment, "could never get it over to profile," may have been in response to the captain's attempt to capture the profile by pushing the profile button twice.

descent rate on approach of 700 to 800 fpm. The NTSB concludes that the captain's change to a vertical speed approach after failing to capture the profile glidepath was not in accordance with UPS procedures and guidance and decreased the time available for the first officer to perform her duties.

2.3.2.2 Pilot Monitoring

The NTSB has long recognized the importance of flight crew monitoring skills in accident prevention. For example, an NTSB safety study of 37 major flight-crew-involved accidents found that, for 31 of these accidents, inadequate monitoring and/or cross-checking had occurred (NTSB 1994). The study found that flight crewmembers frequently failed to recognize and effectively draw attention to critical cues that led to the accident sequence. Pilots' poor flightpath monitoring has continued to be causal and/or contributing to accidents over the last 20 years. The flight crew's performance in this accident appears consistent with pilot monitoring errors that have been identified in other recent major NTSB investigations (NTSB 2004, 2006, 2010, 2011, and 2014).

At 0447:03, when the airplane was about 1,530 ft msl and 2.3 mi from the runway, the first officer made the required 1,000-ft HAT callout. After the 1,000-ft callout, the flight crew did not adequately monitor the descent rate. The airplane was still descending at 1,500 fpm, which was far in excess of the UPS stabilized approach criteria, which required no more than 1,000 fpm below 1,000 ft agl. The NTSB concludes that the flight crew did not monitor the descent rate and continued to fly the airplane with a vertical descent rate of 1,500 fpm below 1,000 ft agl, which was contrary to SOPs, resulting in an unstabilized approach that should have necessitated a go-around.

The flight crew should have continued to monitor the airplane's altitude but did not; neither crewmember noticed that the airplane was nearing or had reached the minimums altitude and the first officer did not make the subsequent required altitude callouts of "approaching minimums" (1,300 ft msl) and "minimums" (1,200 ft msl). These callouts should have elicited either a "landing/continuing" (if the airport was in sight) or "go-around, thrust, flaps" (if the airport was not in sight) response from the captain and would have further alerted the crew to their proximity to the ground. Because the flight crew was flying a nonprecision approach in instrument conditions, extra vigilance was required to ensure that the airplane did not descend below the minimums altitude without the airport being in sight.

The NTSB considered whether, once the profile path did not capture, the captain may have been attempting to use vertical speed to reintercept the glidepath from above or was using a vertical speed "dive-and-drive" approach. Because he did not brief the first officer on his intentions, the captain's exact intentions could not be determined. Although the captain may not have intended to fly a "dive-and-drive" approach, the approach essentially became a "dive-and-drive" approach based on his actions: (1) there was no indication of a glideslope for him to descend to because the VDI never moved from its full-up scale indication; (2) he did not maintain a constant vertical speed descent as depicted on the approach chart;[98] and (3) the captain selected a vertical descent of 1,500 fpm, which is the maximum vertical speed guidance outlined in the AOM for a vertical speed method consistent with "dive and drive."

[98] The approach chart indicated that the rate of descent was 813 fpm to conduct a CDFA.

The captain's belief that the airplane was "way high" on the approach and/or fatigue (see section 2.4.1) likely contributed to his failure to adequately monitor the airplane's descent rate and altitude. The time compression resulting from the excessive descent rate, the first officer's diverted attention, and/or fatigue (see section 2.4.2) likely impeded the first officer's ability to comply with the requirement for these callouts. The airplane reached these altitudes far faster than the first officer would have expected because of the excessive descent rate. Further, although the first officer should have been looking at the barometric altimeter to ensure timely callouts for the PF, given that she did not make the callouts, her attention may have been diverted. At 0447:05, the captain stated that the decision altitude (which, as noted, should have been the minimum descent altitude because of the approach change) was 1,200 ft and, at 0447:08, the first officer replied, "twelve hundred yeah." At this point, the airplane was still about 200 ft above the minimum descent altitude, so it is unlikely that the first officer used this as an unconventional callout at that time. The airplane continued its descent rate of 1,500 fpm. At 0447:11, the captain stated "two miles," which could be consistent with him momentarily referencing the approach chart that indicated that IMTOY was 2 mi from the end of the runway. The airplane passed the IMTOY stepdown fix at an altitude near the prescribed altitude of 1,380 ft msl but continued to descend at 1,500 fpm.

At 0447:19.6, as the airplane was about 90 ft below the minimum descent altitude, the first officer remarked, "it wouldn't happen to be actual [chuckle]," to which the captain responded, "oh, I know," followed 1.5 seconds later by the aural "sink rate" caution alert. The first officer's statement was inconsistent with any known callout and was not likely associated with any annunciation or cue inside the cockpit. Instead, the first officer's remark appears to be more consistent with the weather conditions the flight was encountering during the approach—either a query about the weather as a result of the captain not having announced the airport in sight or a commentary associated with her own observations out the window. Therefore, the NTSB concludes that the flight crew did not sufficiently monitor the airplane's altitude during the approach and subsequently allowed the airplane to descend below the minimum altitude without having the runway environment in sight.

Because the ATIS reported a ceiling of 1,000 ft, the first officer may have expected to break out of the clouds at that altitude. It is quite possible that, after making the 1,000 ft HAT callout, the first officer began to look out the window because she expected that they would soon see the airport environment, even though, unknown to the flight crew, the estimated cloud base was about 350 ft above airport elevation.[99] Her remark of "it wouldn't happen to be actual [chuckle]" likely indicated her realization that her expectations were not being met and that the ceiling was, in fact, lower because although the airplane was continuing to descend, she still did not see the airport. If the remark was associated with the first officer's own attempts to search for the airport environment, she would not be attending to the barometric altimeter to make the callouts. As pilot monitoring, the first officer could quickly glance outside the airplane, but her primary duty was to monitor the instruments.[100] It is conceivable that the first officer believed

[99] Information from video images recorded by a surveillance video camera based at the airport, correlated with information from the CVR and FDR, indicated that the airplane emerged from the clouds at about 1,000 ft msl, or about 350 ft above airport elevation.

[100] UPS procedures required that the PM primarily monitor the instruments and at the "approaching minimums" callout, the PF then would divide attention between inside the cockpit and outside in an attempt to acquire visual reference with the runway environment. The PM would continue to monitor the instruments to make the "minimums" callout.

that looking out the window would not be of consequence (especially because she did not hear the captain call out that the airport was in sight and she expected it to be); however, with the time compression resulting from the excessive descent rate and her fatigued state, it proved catastrophic. The NTSB concludes that the first officer's failure to make the "approaching minimums" and "minimums" altitude callouts during the approach likely resulted from the time compression resulting from the excessive descent rate, her momentary distraction from her PM duties by looking out the window when her primary responsibility was to monitor the instruments, and her fatigue. See section 2.4.2.1 for a discussion of the first officer's fatigue.

Although the first officer did not make the "minimums" callouts, the captain had adequate instrumentation to ensure that he leveled off at 1,200 ft until the airport environment was in sight. As PF in instrument conditions, he should have been primarily monitoring the flight's altitude and dividing his visual scan between the instruments and outside the forward window attempting to acquire the PAPI lights to continue his descent below 1,200 ft msl. Because the captain also likely expected to break out of the clouds at 1,000 ft, he may have been distracted from his PF duties by looking out the window in an attempt to acquire the PAPI lights. The NTSB concludes that, although it was the first officer's responsibility to announce the callouts as the airplane descended, the captain was also responsible for managing the approach in its final stages using a divided visual scan that would not leave him solely dependent on the first officer's callouts to stop the descent at the minimum descent altitude. The NTSB also concludes that the captain's belief that they were high on the approach and his distraction from his PF duties by looking out the window likely contributed to his failure to adequately monitor the approach.

The EGPWS "sink rate" caution alert sounded when the airplane was about 1,000 ft msl (about 250 ft radio altitude and 200 ft below the minimum descent altitude), and the captain reduced the commanded vertical descent speed to about 400 fpm and then reported having the runway in sight. The first officer also reported the runway in sight (further evidence that she was looking out the window and not at the instruments), and the captain disconnected the autopilot. About 1 second later, which was about 30 seconds after the first officer's 1,000-ft height-above-touchdown callout, the CVR recorded the first sounds of impact.

The ASOS at BHM was found to be working normally without any system malfunctions. Although the ATIS reported a 1,000 ft-broken ceiling, the 350-ft cloud cover encountered over the approach path was likely some of the earlier reported clouds that did not continue drifting southward over the ASOS ceilometer equipment and was not noticeable to the weather observer or ATC tower controller. VMC was officially reported over the airport at the time of the accident.

2.4 Flight Crew Performance

The NTSB evaluated a number of criteria, including recent sleep, sleep quality, circadian factors, and time awake, to determine whether the flight crewmembers were experiencing fatigue at the time of the accident. Scientific research and accident and incident data have shown that operating when fatigued can lead to performance decrements (Caldwell 1997, 932-938; Kruger 1989, 129-141; Previc 2009, 326-346; NTSB 2011; and NTSB 2011). The following sections will discuss how fatigue might have affected each pilot's performance during the accident sequence.

The flight crew had been on duty for 1 day before the accident. The previous day's schedule was not unusually demanding and did not result in an extended duty day or reduced rest period the day before the accident. However, the accident occurred about 0447, and the flight crewmembers were awake in opposition to their normal circadian rhythm. Humans naturally follow a diurnal schedule, and the primary circadian trough is from about midnight to 0600, with the window of circadian low generally occurring between 0300 and 0500. Implementing good sleep habits, taking a short nap before reporting for duty, strategically using caffeine, and getting regular exercise are just some of the strategies that pilots can use to prepare for operating during the circadian low (Caldwell and others 2009, 29-59).

2.4.1 Captain's Performance

2.4.1.1 Fatigue Evaluation

Interviews with pilots who knew the captain revealed that he was concerned about his schedules over recent years and that he had told them that the schedules were "killing" him and becoming more difficult. Staff reviewed the captain's schedules for the 60 days before the accident flight to determine if his schedules would result in chronic fatigue (Lasseter 2009, 10-15).[101] Although the captain flew 6 days in a row on his previous three trip pairings, he generally was off duty for 7 or more days between trips, including just before the accident pairing, allowing for adequate time to recover from any sleep debt he may have acquired while on duty.

In addition, his wife indicated that he was in good health, exercised often, and was very happy in the days before the accident. This description of the captain is not characteristic of someone experiencing chronic fatigue. Because the captain had adequate off-duty time to recover from any sleep debt obtained during his previous duty period and his schedule showed that he had adequate rest time available, the captain was not experiencing chronic sleep debt at the time of the accident.

The captain's wife indicated that he slept well the 2 nights preceding the accident, and no information was available to suggest that he did not receive adequate rest on those nights. His wife stated he went to bed between 2130 and 2200 on Sunday night and that his first known activity was on Monday, August 12, about 0552.

The captain took several steps to minimize the effects of fatigue due to the circadian clock before going on duty Monday night. He napped during the day and, after jumpseating to SDF, secured a sleep room at the UPS facility. Based on the available data, he had about 1 hour 20 min of rest opportunity in SDF. Following a 3-hour 54-min duty period on the morning of Tuesday, August 13, the captain had 14 hours 30 min of scheduled rest. According to cell phone and hotel records, the captain had a sleep opportunity of about 9 hours 45 min broken into three rest periods the day before the accident. Daytime sleep is more likely to be fragmented due to the body's inclination to be awake during daylight hours, and fragmented sleep has been shown to be

[101] Symptoms of chronic fatigue include being tired all of the time, having a loss of motivation, and becoming withdrawn.

less restorative than unfragmented sleep (Stepanski 2002, 268-276). However, the captain had adequate opportunity to obtain a full 8 hours of sleep.

The captain spoke with his wife about 1930 and told her that he rested during the day. The captain went on duty about 2036 and flew from RFD to PIA and then PIA to SDF. In SDF, he secured a sleep room. Based on cell phone records and UPS data, the captain had a 2-hour opportunity to nap before departing SDF on the accident flight. The CVR recorded a conversation between the flight crew while on the ramp in Louisville. Between 0341:53 and 0343:34, the crew discussed schedules and rest and fatigue. At 0342:54, the first officer explicitly said she “slept good” in Rockford, and the captain responded “me too.” The first officer further stated that she “was out in that sleep room when my alarm went off I mean I’m thinkin’ I’m so tired.” The captain made no explicit reference to his own rest in SDF but responded, “I know.” Based on the available data, the captain had the opportunity to obtain adequate rest before the accident flight and was not experiencing acute sleep loss.

Although research suggests that appropriately placed naps can improve alertness for up to 24 hours (Dinges 1987), because the accident occurred about 0447 (a time of day associated with a dip in the circadian rhythm), the captain may have been experiencing some fatigue at the time of the accident. Even when well rested, operating during this time of day increases the likelihood of performance decrements (Caldwell 1997; Kruger 1989; Previc and others 2009). However, the captain, in this case, had employed fatigue countermeasures, and most operations that occur during this time of day do not result in accidents. Although other issues, could explain the captain’s performance, the errors and decisions made by the captain may be attributed to factors including, but not limited to, fatigue, distraction, and confusion, consistent with performance deficiencies exhibited during training. The NTSB concludes that for the captain, fatigue due to circadian factors may have been present at the time of the accident.

2.4.1.2 Captain’s Errors

Although pilots who flew with the captain reported that he was qualified and followed procedures, his training records indicate past performance deficiencies that are consistent with the types of errors made during the accident flight. While the deficiencies noted during the captain’s training may not be unusual, they can be predictive of future deficiencies, especially for skills that are not practiced routinely. The captain twice withdrew voluntarily from upgrade training on the 757 (in 2000 and 2002) because he reportedly felt overwhelmed with the program.[102] During captain upgrade training in the A300 in 2009, the captain had deficiencies that required repeating or being debriefed on the scenarios for the following reasons: looking at the radio altimeter instead of the barometric altimeter for height above airport, getting behind on a localizer approach using vertical speed, descending to an incorrect altitude on a nonprecision approach using vertical speed, using vertical speed during a descent when profile or level change would have worked better, using decision altitude instead of minimum descent altitude and flying below minimums, and failing to communicate to the PF that he had an inadequate descent rate. He successfully upgraded to captain on the A300 in June 2009. During recurrent training in 2013, he was required to redo an item when he set his minimums bug incorrectly while

[102] The captain reported this information to one of his former instructors.

performing a nonprecision approach. Most of these errors were associated with flying a nonprecision approach.

The captain is responsible for setting the tone in the cockpit for the entire flight, and this is even more critical during the approach and landing phase of flight when workload is higher. The captain did perform the approach briefing in accordance with the operator's guidance and adhere to SOPs for the takeoff, cruise, and initial descent phases of flight. However, during this flight, the captain demonstrated poor decision-making by continuing the approach after the profile did not capture, failing to communicate the change in the approach method, not monitoring the descent rate and altitude, and failing to initiate a go-around when the approach was unstabilized below 1,000 ft. The NTSB concludes that the captain's poor performance during the accident flight was consistent with past performance deficiencies in flying nonprecision approaches noted during training; the errors that the captain made were likely the result of confusion over why the profile did not engage, his belief that the airplane was too high, and his lack of compliance with SOPs. See section 2.5.5 for a discussion on nonprecision approach proficiency.

2.4.2 First Officer's Performance

2.4.2.1 Fatigue Evaluation

The first officer started the trip pairing on August 10, flying from SDF to SAT for a scheduled layover of more than 62 hours. After arriving in SAT, the first officer took a commercial flight to Houston, Texas, to visit a friend. The first officer's husband reported that, when she was not working, she would typically sleep an estimated 9 to 10.5 hours of sleep per night. On August 10, the first officer had a sleep opportunity of 9 hours 31 min, consistent with her reported off-duty sleep habits. However, despite having over 62 hours off duty, a review of the first officer's PED data revealed that, on the subsequent nights leading up to the accident flight, the first officer did not manage her off-duty time sufficiently to obtain adequate sleep before resuming duty on August 12 about 2053. Specifically, on the night of August 11, the first officer had a sleep opportunity of only 6 hours 27 min. She spent the morning of August 12 in Houston and returned to SAT on a commercial flight, which departed about 1325. Based on her known activities that day, the first officer had only two opportunities to nap before returning to duty: 1 hour 2 min before departing Houston and 1 hour 21 min after arriving in SAT. It could not be determined if the first officer took advantage of these sleep opportunities.

Based on the available data, it appears that the first officer chose to revert to a diurnal schedule during her 62-hour layover, sleeping at night and being awake during the day. During the layover, the first officer visited a friend in Houston. While she reported to her husband that she was tired and sleeping all the time, her PED usage indicated few opportunities for sleep during the layover. Although she was not required to stay in SAT, she was required to arrive for work fit for duty and should have ensured that she received adequate sleep before reporting for duty on August 12. Additionally, UPS would have paid for a hotel room in SAT for the layover, which the first officer could have used to adjust her schedule to a nocturnal one. Adjustment to night activity is possible, and, under ideal conditions, the adjustment occurs about 1 hour per day (Wever 1980, 303-327). However, research suggests that it can be difficult for humans to flip their sleep-wake habits. A NASA study examining pilots in overnight cargo operations found that the circadian clock of pilots did not shift completely. Further, the circadian low is delayed about 3 hours after 5 days of night flying (Gander and others 1998, B26-B36). Because the accident occurred during the window of circadian low, the first officer was awake in opposition to her normal body clock and would have been more vulnerable to the negative effects of fatigue that she was already experiencing.

Even if the first officer did take advantage of the sleep opportunities available on August 12, she would not have been adequately rested for duty. She had likely been up for about 13 hours before reporting for duty with less than a 2 1/2 hour opportunity for sleep, and her duty day required her to be awake for another 9 1/2 hours.

Less than 90 min before going on duty, the first officer texted a friend stating, "I'm getting sooo tired." About 2 hours later, she sent another text stating, "hey, ba[c]k in the…office, and I'm sleepy...." The first officer's duty period consisted of three legs: SAT to SDF, SDF to PIA, and PIA to RFD, departing SAT about 2151 and arriving in RFD about 0553 on August 13 (during the 2 hours 59 min in SDF, she did not secure a sleep room). At this point, the first officer would likely have been experiencing a sleep debt in excess of 9 hours.

During the 14-hour 30-min layover in RFD on August 13, based on her known activities, the first officer had two sleep opportunities of about 3 hours 54 min and 1 hour 22 min (from 0649 to 1043 and 1705 to 1827).[103] This total sleep opportunity was less than the recommended 7 to 9 hours for adults and less than her typical sleep. In addition, she did not afford herself the opportunity to obtain additional sleep as evidenced by her repeated PED usage and the fact that she was out of her room from about 1100 to 1522. As noted previously, fragmented sleep has been shown to be less restorative than unfragmented sleep. A pilot is responsible for taking measures to obtain adequate rest and be fit for duty. The first officer was aware of her fatigued state as she texted a friend about 1118, stating, "u got that rite, i fell asleep on every…leg last nite- n rfd now, got here at 6 am n bed by 645 ish, now…up, slept like 4…hrs…hoping i will nap again this afternoon." Given the first officer's discussions with friends about her fatigue, she should have used her off-duty time more effectively to obtain as much sleep as possible.

The first officer went back on duty about 2036 and flew with the accident captain from RFD to PIA and then from PIA to SDF. In SDF, the first officer obtained a sleep room and had a sleep opportunity of about 1 hour 51 min. The CVR recorded the first officer telling the accident captain that she slept in the sleep room. As noted previously, she further stated she was tired when her alarm went off before the accident flight. About an hour had elapsed when this conversation was recorded on the CVR and, at the time of the accident, about 2 hours had elapsed from when the first officer awoke from her nap; therefore, she should not have been experiencing sleep inertia during the accident flight.[104] There was no follow-up discussion by the captain about whether the first officer was fit for duty. Even if the first officer had been able to take advantage of the full rest period in RFD and the sleep opportunity in SDF, due to the excessive sleep debt acquired over the previous 2 days due to her personal choices and the accident flight occurring during the window of circadian low, it is unlikely that she would have

[103] A third extended break in the first officer's known activities of 1 hour 55 min (from 1148 to 1343) occurred on August 13; however, after the first officer was observed in the hotel restaurant having breakfast, she did not swipe her key back into her room until 1522. Her whereabouts during that time could not be determined.

[104] Sleep inertia is the grogginess or sleepiness that a person may feel after awakening and typically dissipates about 10 to 15 min after awakening but can last about 35 min (Rosekind and others 1995, 62-66). Either the first officer's acquired sleep debt or sleep inertia could explain why she felt tired when she awoke from her nap.

been able to fully recover and be adequately rested for any of her duty period that began on the evening of August 13.

Although the errors the first officer made during the accident flight cannot be solely attributed to fatigue, the first officer made several errors consistent with the known effects of fatigue. Specifically, the first officer did not clear the route discontinuity in the FMC (something that should be almost automatic, as it is done on every UPS flight), did not recognize cues suggesting the approach was not set up properly, did not adequately cross-check and monitor the approach (especially below 1,000 ft), and missed critical callouts. Although some of these errors may have resulted, in part, from distraction while looking for the airport, time compression, and her confusion about the change in approach modes, fatigue likely further negatively affected the first officer's performance. Nothing in the first officer's training records indicated any problems with her PM skills.

In summary, there were several decisions made by the first officer that contributed to her fatigue, which could have been mitigated by alternate choices. The first officer could have more effectively managed her sleep/wake schedule during her extended layover in San Antonio to minimize further adverse effects when she returned to night duty on August 12. Additionally, the first officer could have taken full advantage of her sleep opportunities in the days preceding the accident but instead she had extensive PED use, the timing of her return trip from Houston to SAT, did not secure a sleep room in SDF on the morning August 13, and later that day was outside of her hotel room for about 5 hours. Finally, when the first officer recognized that she was tired, she could have followed company guidance and called in fatigued. The NTSB concludes that the first officer poorly managed her off-duty time by not acquiring sufficient sleep, and she did not call in fatigued; she was fatigued due to acute sleep loss and circadian factors, which, when combined with the time compression and the change in approach modes, likely resulted in the multiple errors she made during the flight.

2.4.3 UPS and IPA Fatigue Mitigation Efforts

UPS has a comprehensive FRMP that includes fatigue training, stricter flight- and duty-time limitations than required by Part 121 Subpart Q per the UPS/IPA collective bargaining agreement, and data collection and analysis. UPS also encourages joint responsibility between the company and the pilots to prevent and mitigate fatigue. UPS provides the Flight Crew Alertness Guide, which contains recommendations and tips for obtaining adequate rest and maintaining alertness on the flight deck. As noted previously, the accident occurred during the window of circadian low, a time that many cargo operators conduct their flights.

UPS pilots were required to perform a CRM/safety briefing before each flight, in part, for the captain to set the tone in the cockpit, but the briefing did not include the threat of fatigue. UPS and FAA personnel indicated that while fatigue could be briefed as a threat, it was not required; therefore, the frequency that fatigue was briefed as a threat varied from every flight to never based on the pilot's preference. UPS fitness for duty policy notes, "This [fitness for duty] decision is vital to safety and the notification must occur without hesitation. UPS Crew Scheduling will remove the crewmember from service and provide further assistance, as required." The NTSB concludes that, given the increased likelihood of fatigue during overnight operations, briefing the threat of fatigue before every flight would give pilots the opportunity to identify the risks associated with fatigue and mitigate those risks before taking off and throughout the flight. Therefore, the NTSB recommends that the FAA require principal operations inspectors (POIs) to ensure that operators with flight crews performing 14 CFR Part 121, 135, and 91 subpart K overnight operations brief the threat of fatigue before each departure, particularly those occurring during the window of circadian low. Additionally, the NTSB recommends that UPS and IPA work together to conduct an independent review of the fatigue event reporting system to determine the program's effectiveness as a nonpunitive mechanism to identify and effectively address the reported fatigue issues. Based on the findings, implement changes to enhance the safety effectiveness of the program.

The NTSB has had longstanding concerns about fatigue in aviation, and, for many years, this issue was on the NTSB's Most Wanted List. The FAA recently issued new flight- and duty-time regulations for Part 121 operations that went into effect on January 4, 2014. However, these regulations do not apply to all-cargo operations. The NTSB has stated that it believes that the FAA should include all Part 121 operations under the new rules. Although all-cargo operators can voluntarily choose to follow these regulations, UPS has not. Following the NTSB's investigative hearing, the UPS director of safety submitted correspondence stating that the Part 117 rules "would not enhance safety for cargo carriers, yet would impose high and unnecessary costs." He added that UPS "has been a pioneer in fatigue management techniques, going above and beyond the regulations where appropriate" and that its collective bargaining agreement with IPA "contains a detailed scheduling article on flight, duty, and rest time…[that] ha[s] enhanced UPS's safe and effective approach to these issues."

Although, at the time of the accident, Part 117 was not in effect for any operations, the NTSB asked the FAA to compare the accident flight crew's schedule for their entire pairing[105] to Part 117 regulations. The FAA determined that the pairing would have met Part 117 regulations for both flight crewmembers. However, for the previous 60-day schedule, the captain would have had one rest period that did not meet the minimum requirement (it was 9 min short), and twice his schedule would have been 1 day beyond the Part 117 nighttime flight duty period requirements. The NTSB reviewed the FAA's determination and concurs with its findings. The NTSB concludes that the schedule the flight crew was flying would have been in compliance with 14 CFR Part 117 requirements had those requirements been in effect and applied to all-cargo operators.

The UPS fatigue policy stated that crewmembers who called in fatigued would be immediately removed from duty until they felt fit to fly again. The crewmember was then required to complete a fatigue event report that would be reviewed by company and union representatives to determine if the company or the crewmember was responsible for the fatigue. If it was determined that the crewmember was responsible for being fatigued (for example, if the crewmember mismanaged off-duty time), the crewmember's sick bank would be debited for the time not flown. The UPS fitness for duty policy stated, "UPS crewmembers are expected to report for all assignments fit for duty. Further, UPS crewmembers are prohibited from operating aircraft if they are not fit for duty… Fitness for duty includes, but may not be limited to, being free from illness, injury, fatigue, scuba diving restrictions, blood donations, alcohol, drugs, etc." Additionally, the FOM stated the following:

- Do not operate as a crewmember if fatigue compromises your ability to safely perform your assigned duties. Crewmembers are expected to report for duty rested

[105] The pairing was 4 days for the captain and 7 days for the first officer.

and prepared for scheduled duty periods. Duty periods may include revision or reschedule as defined by the Collective Bargaining Agreement.

- **NOTE:** In addition to notifying Crew Scheduling, crewmembers who determine they cannot perform assigned duties due to fatigue, are required to complete a Fatigue Event Report.
- Refer to the "Fatigue Risk Management" section of Chapter 05, Crew Resource Management (CRM) for additional guidance.

Although no letter would be placed in a crewmember's file for calling in fatigued, it would be noted in the crewmember's record that a fatigue call was made. An IPA representative believed this to be a punitive action; however, four of the six pilots interviewed who had called in fatigued said that having done so would not stop them from calling in fatigued again.

Company documentation of a fatigue call is understandable because it ensures that crewmembers are not abusing the system and helps determine whether a particular crewmember has a systemic issue causing fatigue. Further, pilots' salaries are not directly affected by a fatigue call; rather, their sick banks are debited if it is determined that their personal activities led to the fatigued state. However, UPS's unique sick bank policy, in which pilots are paid at the end of each year for any sick time not used throughout the year, could discourage pilots from calling in fatigued because they wanted to maximize this year end "bonus." However, it should be noted that crewmembers whose sick bank is debited following a fatigue call can repay their sick bank within the current or next two pay periods by picking up an extra trip. Therefore, the NTSB concludes that the first officer did not adhere to the UPS fatigue policy; she could have called in fatigued for the accident flight if she were not fit for duty and been immediately removed from duty until she felt fit to fly again.

Crewmembers are responsible for arriving at work fit for duty, and the union can serve an important function in encouraging and educating its members on being fit for duty. During the NTSB's February 20, 2014, investigative hearing on this accident, the IPA representative stated that the IPA had published a few articles on fatigue (for example, in 2011, it published an article in the IPA *SAFER Skies* magazine that focused on good sleep habits and fatigue countermeasures) but that it provided no additional guidance on fatigue to its members. The union can play a critical role in counseling its members on whether they are fit for duty and counseling them to call in fatigued when necessary. The union can also provide additional information on fatigue countermeasures and personal responsibility to members who do call in fatigued and whose sick bank is debited. The NTSB concludes that, by providing fatigue counseling, UPS and IPA would help to increase pilot awareness and understanding about fatigue and may provide a valuable resource in understanding fatigue calls. Therefore, the NTSB recommends that IPA and UPS work together to counsel pilots who call in fatigued and whose sick bank is debited to understand why the fatigue call was made and how to prevent it from recurring.

2.5 Operational Issues

2.5.1 Dispatcher Training

Per 14 CFR 121.533, the pilot-in-command and the dispatcher work together to ensure that all aspects of the operation of a flight are conducted safely. This cooperation depends on both the pilot-in-command and dispatcher working from the same information related to the flight to make safety-related decisions. Dispatchers are taught DRM principles, much like CRM principles are taught to pilots. According to the UPS FOTM and the flight control manager who testified at the NTSB's investigative hearing, one of the objectives of DRM is improved interface or contact with each pilot-in-command. FAA AC 121-32A, "Dispatch Resource Management Training," provides guidance on DRM. The AC encourages joint training between dispatchers and all operational personnel (including pilots) and notes the importance of communication and instruction in developing and refining the dispatchers' communication skills.

UPS dispatchers received about 18 hours of initial DRM training and 1 hour of DRM training during recurrent annual training, none of which is conducted jointly with pilots. Because pilots and dispatchers do not interact during DRM training (and because pilots do not even receive DRM training), communication between a dispatcher and pilot may be hampered by misunderstandings about the role each one plays in the flight-planning process.

The accident flight dispatcher told investigators that he typically did not talk to pilots unless they initiated the conversation. However, a UPS flight control shift manager said that UPS dispatchers had multiple means to interact with a flight crew, including via cell phone or land line, satellite communications, the Aircom Server on most airplanes, or the ACARS. Reasons for interaction could include discussion about significant weather en route or at the destination or limited approach options.

The accident flight dispatcher reported that he and the accident pilots did not communicate with each other before the accident flight. Although it is not required that pilots and dispatchers communicate before every flight during normal operations and a verbal dispatch briefing is not required before every flight, the basic tenets of CRM and DRM suggest that both pilots and dispatchers share information that may affect the safety of a flight and should not assume the other is already aware of any issue identified.

Further, both dispatchers and pilots have the operational authority to delay a flight, although UPS did not have a specific policy as to when or under what specific circumstances a dispatcher could delay a flight. Because the dispatcher and flight crew were jointly responsible for the safety of the flight, if the dispatcher or captain had delayed the flight by 9 min from its scheduled 0451 arrival time,[106] runway 06 with an ILS precision approach was scheduled to be open and potentially would have provided the flight crew with the option to execute a more familiar ILS precision approach to runway 06. However, as noted earlier, while the dispatcher was aware that runway 06 was closed, the flight crew did not appear to be aware of this closure based on their apparent surprise when they received the ATIS briefing for a runway 18 landing. While the dispatcher may have been reluctant to communicate with the flight crew by alerting them to the closure, DRM training could have given him the confidence to communicate with and ensure the flight crew was aware of this information. Further, the flight crew, with joint dispatcher training, may have been more apt to converse with the dispatcher about any potential safety issues for the flight.

[106] The NTSB is aware of at least one cargo operator scheduled to land at BHM around the same time as the accident flight that delayed its arrival in order to land on runway 6.

As noted, UPS dispatchers and pilots, who are jointly responsible for the safety of a flight per 14 CFR 121.597, do not train together, which may have hampered communication between the dispatcher and the flight crew. If pilots and dispatchers are aware of their roles and responsibilities and understand where communication breakdowns may occur, the communication between them could be improved. Therefore, the NTSB concludes that a joint dispatcher/pilot training module, specific to CRM and DRM principles, would facilitate improved communication between pilots and dispatchers and enhance their understanding of the challenges and capabilities of the pilot/dispatcher roles in the safe operation of the flight. As a result, the NTSB recommends that the FAA require operators to develop an annual recurrent DRM module for dispatchers that includes participation of pilots to reinforce the need for open communication.

2.5.2 Crew Briefings

The UPS A300 AOM stated, “crew briefings are a critical part of the cockpit communications process. They should be used to supplement SOPs; aiding each crewmember in understanding exactly what is expected during taxi, takeoff, approach and landing.” According to the UPS flight standards and training manager’s testimony at the NTSB’s investigative hearing, an approach briefing provides both pilots a “shared mental model” (that is, an understanding) of how the approach is going to be conducted. The UPS flight standards and training manager further stated that “if an element within that approach briefing were to change, the expectation would be either to re-brief it if there’s time to do that before initiating the actual approach, or build yourself some time, which would be either take a turn in holding, take radar vectors, or essentially abandon that particular approach.”

The UPS AOM does not specifically instruct pilots to rebrief or abandon the approach if the type of approach changes. However, when the UPS director of operations was asked during the NTSB’s investigative hearing about the flight crew’s responsibility to rebrief or abandon the approach, he stated, “it would be the expectation.” Yet the captain, when he noticed that the airplane was not descending on the profile as planned, changed the autopilot from the profile mode to the vertical speed mode without briefing the first officer. She had to seek out information on this autopilot mode change. The purpose of briefing any change in the approach is to ensure that crewmembers have a shared understanding of how the approach will be flown. By not briefing the autopilot mode change, the first officer’s situational awareness was degraded. Therefore, the NTSB concludes that by not rebriefing or abandoning the approach when the airplane did not capture the profile glidepath after passing the FAF, the flight crewmembers placed themselves in an unsafe situation because they had different expectations of how the approach would be flown. Therefore, the NTSB recommends that the FAA require POIs to work with operators to ensure that their operating procedures explicitly state that any changes to an approach after the completion of the approach briefing should be rebriefed by the flight crewmembers so that they have a common expectation of the approach to be conducted.

2.5.3 Enhanced Ground Proximity Warning System Alerts and Response

At 0447:24.5, CVR and FDR data indicated that the pilots received an EGPWS aural "sink rate" caution alert at an altitude of about 250 ft agl while descending about 1,500 fpm.[107] The FDR recorded a reduction in the commanded vertical speed on the mode control panel shortly thereafter. However, the airplane began to strike the trees 8 seconds after the sink rate alert. About 1 second after striking the trees, the CVR recorded an EGPWS "too low terrain" caution alert.

In accordance with the A300 AOM, UPS A300 pilots were trained to respond to a "sink rate" caution alert by either adjusting the pitch attitude or applying thrust to silence the alert.[108] However, EGPWS guidance in the UPS A300 PTG stated that if a "sink rate" caution alert was received while operating in IMC, the PF must perform a go-around or the CFIT recovery maneuver, as appropriate. Thus, the PTG distinguished between the appropriate responses to a "sink rate" caution alert in IMC and VMC, and that distinction was absent from the AOM guidance. During the NTSB's investigative hearing for this accident, the UPS flight standards and training manager said that "for a sink rate alert to go off, [the approach has] to be unstabilized," and, thus, a go-around would be the appropriate response. However, this statement goes beyond the AOM guidance that indicated that only adjusting the vertical speed using pitch attitude or applying thrust in response to a "sink rate" caution alert (which the captain did) was necessary. The captain's actions in response to the alert were consistent with the guidance provided in the AOM, but not the PTG.

Another example of inconsistent guidance relates to the EGPWS "too low terrain" alert. Although the pilots did not receive a caution alert until after the airplane had struck the trees, a review of the AOM and PTG guidance indicated differences between the recommended responses to a "too low terrain" alert, which could create confusion for pilots on which procedure to use when such an alert occurs. Specifically, the PTG contained more aggressive guidance than the AOM for pilots addressing "too low terrain" alerts, indicating that pilots should perform the aggressive CFIT avoidance maneuver, which involved disengaging the autopilot, rotating the airplane 20º nose up, applying maximum thrust, retracting the speedbrakes, and rotating further, up to stick shaker if required. The AOM stated that the pilot should adjust the flightpath or go around. Although the PTG included more aggressive response procedures, UPS A300 pilots were trained and evaluated on their responses to the EGPWS alert based on the less aggressive guidance contained in the FAA-approved AOM, which was similar to the Airbus information.

Because the EGPWS provides critical information to help a pilot avoid terrain, it is imperative that pilots receive appropriate and consistent training so that the response is immediate. Had the captain performed the CFIT-avoidance maneuver in response to the "sink rate" alert as specified in the PTG, performance data showed that the airplane could have avoided terrain. Additionally, there may have been adequate time to perform a successful go-around. Therefore, the NTSB concludes that the captain's moderate response to the EGPWS "sink rate" caution alert (adjusting the flight's vertical speed) was consistent with AOM

[107] The NTSB notes that the approach was unstabilized when the airplane passed through 1,000 ft AFE at a descent rate of 1,500 fpm and that the pilots should have conducted a go-around at that point.

[108] Review of Airbus guidance showed that for a sink rate alert, the flight crew should adjust the pitch attitude and thrust to silence the alert.

guidance and training; however, the response was not sufficient to prevent striking the trees on the approach and was not consistent with the more conservative guidance in the PTG. Therefore, the NTSB recommends that the FAA require POIs to ensure consistency among their operators' training documents, their operators' FAA-approved and -accepted documents, such as the AOM, and manufacturers' guidance related to TAWS caution and warning alert responses, and ensure that responses are used during night and/or IMC that maximize safety.

2.5.4 Continuous Descent Final Approach Technique

As noted previously, a CDFA is a specific technique for flying the final approach segment of a nonprecision instrument approach as a continuous descent, without level-off, from a specific altitude near the FAF to a point about 50 ft above the landing runway threshold or the point where the flare maneuver should begin for the type of aircraft flown. FAA AC 120-108 describes and recommends the use of the technique of a stable continuous descent path in lieu of the traditional "dive and drive" type of nonprecision approach, which can lead to unstabilized approaches because of multiple thrust, pitch, and altitude adjustments inside the FAF. Although the flight crew set up and briefed a CDFA approach using the profile method, when the captain changed the autopilot to vertical speed mode, the approach essentially became a "dive and drive" approach. Per the guidance and training provided at UPS, both approach options were available to flight crews. Although CDFA was one of the techniques taught at UPS, the guidance for CDFA was found in the PTG, which is not an FAA-approved or -accepted manual.

As stated in FAA AC 120-108, CDFA requires no specific aircraft equipment other than that specified by the nonprecision approach procedure. It also minimizes the risk of unstabilized approaches and CFIT.[109] The NTSB concludes that the CDFA technique provides a safer alternative to "dive and drive" during nonprecision approaches.

As noted previously, in response to Safety Recommendation A-06-8, which asked the FAA to incorporate the constant-angle-of-descent technique into their nonprecision approach procedures and to emphasize the preference for that technique where practicable, the FAA stated that it would include a requirement for training on and incorporation of the constant-angle-of-descent technique in its final rule on "Qualification, Service, and Use of Crewmembers and Aircraft Dispatchers." However, the final rule did not contain such a requirement. While the FAA has indicated that it favors the use of CDFA, the use of the approach is in guidance material only, and operators are not required to incorporate the

[109] International Civil Aviation Organization (ICAO) Doc 8168, Vol. I, Part I, Amdt 3, 1.7.1, states "Studies have shown that the risk of controlled flight into terrain (CFIT) is high on non-precision approaches. While the procedures themselves are not inherently unsafe, the use of the traditional step down descent technique for flying non-precision approaches is prone to error, and is therefore discouraged. Operators should reduce this risk by emphasizing training and standardization in vertical path control on non-precision approach procedures. Operators typically employ one of three techniques for vertical path control on non-precision approaches. Of these, the continuous descent final approach (CDFA) technique is preferred. Operators should use the CDFA technique whenever possible as it adds to the safety of the approach operation by reducing pilot workload and by lessening the possibility of error in flying the approach." Further, many ICAO Contracting States require the use of the CDFA technique and apply increased visibility or runway visual range (RVR) requirements when the technique is not used. For instance, the EU Ops 1, OPS 1.430, Appendix 1, (d)2, states: "All non-precision approaches shall be flown using the continuous descent final approaches (CDFA) technique unless otherwise approved by the Authority for a particular approach to a particular runway. When calculating the minima in accordance with Appendix 1 (New), the operator shall ensure that the applicable minimum RVR is increased by 200 metres (m) for Cat A/B aeroplanes and by 400 m for Cat C/D aeroplanes for approaches not flown using the CDFA technique, providing that the resulting RVR/CMV value does not exceed 5000 m."

information into their manuals; the FAA also has no mechanism to ensure that carriers are using the CDFA technique and training flight crews to use it. Further, although UPS included the CDFA technique in its PTG and trained flight crews on the technique, it did not require flight crews to use the CDFA when performing nonprecision approaches. In addition, the FAA did not require that the CDFA be included in UPS's FAA-approved documents nor did they require the inclusion of a prohibition against the use of "dive and drive" approaches in those documents. [110] Because of the safety benefits associated with CDFA, the NTSB believes that FAA-approved nonprecision instrument landing procedures should comply with guidance in AC 120-108 and the FAA must do more to ensure that operators incorporate the CDFA technique in their training and manuals for all nonprecision approaches. Therefore, the NTSB recommends that the FAA require principal operations inspectors of 14 *Code of Federal Regulations* Part 121, 135, and 91 subpart K operators to ensure that FAA-approved nonprecision instrument approach landing procedures prohibit "dive and drive" as defined in AC 120-108. Because the FAA did not incorporate the constant-angle-of-descent technique in their final rule on flight crew training, the NTSB classifies Safety Recommendation A-06-8 "Closed—Unacceptable Action/Superseded."

2.5.5 Nonprecision Approach Proficiency

Flight crews can conduct precision or nonprecision approaches. Due to the improved navigation guidance associated with precision approaches, which have a ground-based vertical component, pilots typically conduct them rather than nonprecision approaches, which create a vertical component through navigation systems on the airplane (such as a CDFA approach) or use a step-down approach. Nonprecision approaches with GPS-based vertical guidance are also becoming more prevalent at airports previously only equipped with lateral guidance to the runway as a result of technology advancements and aircraft capabilities.

The precise lateral and vertical guidance provided by an ILS allows lower minimums and promotes more stable approaches; therefore, ILS approaches are preferred by operators and are more familiar to pilots than nonprecision approaches. According to interviews and testimony from the UPS A300 check airman at the NTSB's investigative hearing, although pilots are trained annually on nonprecision approaches, they rarely conduct actual nonprecision approaches during line operations. In most cases, a UPS pilot's only opportunity to practice nonprecision approaches would likely occur once a year during recurrent training. An unintended consequence of the operational preference for precision approaches is that pilots have lost proficiency with the unique procedures associated with infrequently conducted nonprecision approaches.

The NTSB notes that, if pilots practice procedures that they do not use frequently during line operations, their knowledge and skills relative to those procedures will be reinforced. In SAFO 13002, "Manual Flight Operations," dated January 4, 2013, the FAA states that the continuous use of autoflight systems (for example, autopilot or autothrottle/autothrust) on modern aircraft does not reinforce pilots' knowledge and skills in manual flight operations; the SAFO encourages operators to promote manual flight operations when appropriate. Similarly, one reason for the higher occurrence of unstabilized approaches noted in FAA AC 120-108 may be line pilots' lack of reinforced skills in flying nonprecision approaches. Although the flight

[110] Several carriers have voluntarily revised their procedures and require crews to conduct CDFA descents for all nonprecision approaches, prohibiting "dive and drive."

crew had been trained to proficiency in nonprecision approach procedures, due to their limited use of nonprecision approaches, some of that proficiency was likely lost.

In response to Safety Recommendation A-00-11, which asked the FAA to require nonprecision approach practice under specific conditions, the FAA stated that practicing nonprecision approaches was not necessary because it had developed an industrywide strategy that focused on stabilized approaches, including always using a constant-angle-of-descent technique, for all nonprecision approaches. However, even though 14 years have passed, this technique has not been universally implemented throughout industry. Simply issuing an AC does not ensure that operators incorporate the guidance. As stated above, although UPS trained its flight crews on the CDFA technique, it was not required to be used, and its use was abandoned in this accident when the captain switched to a vertical descent method (essentially a "dive and drive"). Further, UPS did not require that its flight crews practice nonprecision approaches, and the FAA has no such requirement for operators.

An ASRS search revealed 62 reports related to nonprecision approaches, 9 of which were similar to the circumstances of this accident. In addition, industry data showed that, when comparing the approaches to ILS runways with nonILS runways at the 31 airports examined, the rate of vertical speed exceedance on approaches to ILS runways was 1/3 the rate of exceedance on nonILS runways. The industry data also showed that, at those same airports, the rate of EGPWS warning alerts for ILS approaches was 1/3 the rate for nonILS approaches; such a warning is not expected for a stabilized approach. The NTSB concludes that, if operators identified and implemented ways for pilots to receive more opportunities to maintain proficiency in nonprecision approaches, pilots could conduct such approaches more safely.

2.5.6 Weather Dissemination

Maintaining awareness of weather conditions for landing is critical to the safety of flight. In this accident, the pilots were not aware that the variable ceiling was so close to ground level because they did not receive this pertinent information in their flight departure papers, via ACARS in flight, or from ATIS on approach even though the remarks sections in METAR and SPECI reports noted the information. Dispatch paperwork provided to pilots typically includes multiple METARs that enable the pilots to assess trending weather information. Further, the remarks section of METARs disseminated to flight crews via the dispatch paperwork, ACARS, or ATIS can contain valuable information to assist in the crew's assessment of potential weather conditions at the airport and along the approach.

In this case, had the remarks section of the METARs been provided to the crew, they may have identified that the ceilings were varying for several hours before the accident and this information may have made them more aware that the ceiling may not be what they expected. Although the 0404 CDT SPECI reported that variable ceilings were no longer present, the flight crew never received this report. Making the flight crew aware of the variable ceilings present earlier may have raised their expectations that there could be clouds fairly low to the ground along the approach. This lack of awareness of the pertinent remarks may have played a role in their expectation that they would see the airport immediately after passing the minimum descent altitude; however, they did not see the airport and continued the descent while they continued to look for the airport.

The Lido weather feed provides information to a UPS database that supplies weather information for the flight departure papers and ACARS weather requests. However, in September 2011, in response to UPS's request to delete the remarks section due to duplicate weather alerts, Lido discontinued providing the supplemental feed of METAR data and the remarks section for METARs to flight departure papers and ACARS. Although all remarks may not be pertinent to flight crews, having critical information readily available can help pilots assess current and anticipated weather conditions.

For the accident flight, the UPS Lido system issued a weather document that included the reports and forecasts for the departure, destination, and alternate airports; however, the weather document did not include clarifying information in the remarks section of the METAR or SPECI observation concerning the variable ceilings. Omission of the remarks section of the reports in this case prevented the pilots and dispatcher from seeing the information about the variable ceilings from 600 to 1,300 ft that was being reported at the destination; instead, they would only have been aware of the reported sky condition.

Title 14 CFR 121.601 requires the dispatcher to provide all available weather reports and forecasts of weather phenomena that may affect the safety of flight. However, by removing the remarks, UPS failed to provide the accident flight crew with pertinent weather information they could have used in planning their approach to BHM. Specifically, the variable ceiling remarks would have indicated that the approach would likely require descent closer to the ground in IMC below the ceiling information provided to the crew. Although UPS has modified its Lido system to provide the remarks section of METARs, other dispatchers or dispatch systems may not provide the remarks, and, as stated above, the remarks can be critical.

ATC personnel based the ATIS Papa report of 1,000-ft broken ceiling on the 0353 METAR observation, which included a reported variable ceiling between 600 and 1,300 ft agl in its remarks section; however the remarks were not included in ATIS Papa. ATC personnel did not update the ATIS with the 0404 SPECI, which no longer included a report of a low ceiling.

The FAA requires ATC personnel to include "pertinent remarks" in the ATIS broadcast, but limited guidance on what constitutes pertinent remarks is available to controllers; therefore, the interpretation of a "pertinent remark" remains subjective. Other weather guidance, such as the NWS *Federal Meteorological Handbook*, provides much more detail on what types of weather would require a pertinent remark. If the flight crewmembers had been aware of the variable ceilings reported on the 0353 METAR, they may not have expected to break out of the clouds at 1,000 ft agl.

Although the controller's failure to update the ATIS with pertinent METAR remarks was satisfactorily addressed locally by ATC facility management after the accident, the NTSB determined during the investigation that similar errors related to the lack of inclusion of pertinent remarks in ATIS broadcasts had occurred at facilities throughout the United States. A random sampling of ATIS broadcasts found that many cases of variable ceiling and visibility in the METAR remarks section, similar to those reported in this accident, were not typically included and were not provided to pilots in the terminal area.

The NTSB concludes that, due to the importance of pertinent remarks, such as variable cloud ceilings, to the flight crew's understanding of weather conditions, it is critical that flight dispatch papers, ACARS, and ATIS contain pertinent remarks for weather observations because such remarks provide flight crews a means to understand changing weather conditions. Had the flight crew been provided with the pertinent remarks in this accident, they may have been aware of the possibility of changing visibility and ceilings upon their arrival at BHM. Therefore, the NTSB recommends that FAA require that the remarks section of METAR reports be provided to all dispatchers and pilots in flight dispatcher papers and through ACARS. Additionally, the NTSB recommends that the FAA expand the current guidance available in FAA Order 7110.65, "Air Traffic Control," to further define METAR pertinent remarks. The NTSB also recommends that the FAA issue a safety advisory bulletin to air traffic controllers providing examples of the types of METAR remarks information considered pertinent and reminding them of the requirement to add such pertinent remarks to ATIS broadcasts.

2.6 Systems Issues

2.6.1 Enhanced Ground Proximity Warning System Software

Postaccident evaluation of the accident EGPWS indicated that it operated per its design during the accident flight. However, the NTSB notes that, if the airplane had been equipped with a newer version of EGPWS software available at the time of the accident, the airplane would have entered the terrain clearance floor alert envelope about 200 ft agl and 1.3 nm from the runway threshold, and a "too low terrain" caution alert would have sounded about 6.5 seconds earlier and 150 ft higher than the EGPWS alert the flight crew received. As noted previously, the airplane's descent rate when it entered the terrain clearance floor envelope was about 1,450 fpm, which would have reduced the effectiveness of the alert. Although simulator results indicate that the updated EGPWS software would provide a significant improvement in alert safety margins and that the airplane could have avoided terrain if the CFIT avoidance maneuver had been executed within 2.4 seconds of the earlier "too low terrain" alert, it was not possible to determine whether the pilots would have, in fact, performed that maneuver or performed it in time to avoid terrain.[111]

The NTSB concludes that the newer EGPWS software, part number 965-0976-003-218-218 or later, will provide an advanced alert and significantly improve safety margins, although its effect on the outcome of this accident is unknown because it cannot be determined how aggressively the pilots would have responded to an earlier "too low terrain" alert. As a result, the NTSB recommends that the FAA issue a special airworthiness information bulletin to notify operators about the circumstances of this accident and the potential safety improvements related to the Honeywell EGPWS part number 965-0976-003-218-218 or later software update.

Although TAWS have significantly reduced the frequency of CFIT accidents, they are still constrained by inherent limitations in data[112] that can significantly affect their performance, even to the point of rendering certain warnings useless (such as the "too low terrain" caution alert in this case). In this accident, the "sink rate" caution alert was the only useful EGPWS alert

[111] The NTSB notes that the descent was unstabilized and the flight crew should have gone around much earlier in the approach.

[112] These limitations include uncertainties in the airplane's knowledge of its own position and uncertainties in the database containing the position of runway thresholds. These uncertainties act to lower the terrain clearance floor envelope (moving them closer to the terrain) so as to avoid nuisance alerts.

received before impact. Because of the desensitized nature of the alerts as the airplane neared the airport, no warning alert was provided. A warning alert would have required a more aggressive response from the pilots to prevent impact with terrain.

The intent of providing two levels of alerts is that the pilot will receive an escalating series of alerts (for example, one or more caution alerts followed by one or more warning alerts) as a collision with terrain or obstacles becomes more imminent. Consistent with this intent, pilots are instructed to respond more aggressively to warning level alerts than to caution alerts. For example, the UPS guidance for a response to a warning level alert is to perform the CFIT recovery maneuver, while the guidance for the response to a caution level alert varies from "adjust pitch attitude and thrust to silence the warning" to "perform a go-around." In this accident, the captain's response was consistent with UPS AOM guidance and training to the "sink rate" caution alert.

The UPS guidance is consistent with the intent of two levels of the EGPWS alerts and with guidance provided by the airplane manufacturer. This guidance reflects the expectation that an inadequate response to a caution level alert will lead to a more urgent warning level alert as the airplane nears terrain and that the warning level alert will occur in time for an aggressive response (such as the CFIT recovery maneuver) to prevent a collision. However, this accident demonstrates that this sequence of events may not occur in certain situations, particularly when an airplane is in the landing configuration and close to the airport. Therefore, the NTSB concludes that an escalating series of TAWS alerts before impact with terrain or obstacles is not always guaranteed due to technological limitations, which reduces the safety effectiveness of the TAWS during the approach to landing. Therefore, the NTSB recommends that the FAA advise operators of aircraft equipped with TAWS of the circumstances of this accident including that, in certain situations, an escalating series of TAWS warnings may not occur before impact with terrain or obstacles. Encourage operators to review their procedures for responding to alerts on final approach to ensure that these procedures are sufficient to enable pilots to avoid impact with terrain or obstacles in such situations.

As stated above, the EGPWS alerting envelopes are reduced when an airplane is in the landing configuration and close to the airport to provide a balance between safe alert timing and nuisance alerts. However, the circumstances of this accident reveal that the EGPWS terrain clearance floor envelope can be ineffective when the airplane is descending at an unusually high descent rate, which is precisely when it is critical that a flight crew receive a warning alert as the airplane nears the ground. In March 2014, a special committee was established to develop an industry consensus set of TAWS standards reflecting the mature nature of this technology and incorporating enhanced requirements and new capabilities. This minimum operational performance standard will form the basis for the next TSO for TAWS and will take into account the improved technology available today. Therefore, the NTSB recommends that the FAA revise the minimum operational performance standards to improve the effectiveness of TAWS when an airplane is configured for landing and near the airport, including when the airplane is descending at a high rate and there is rising terrain near the airport.

2.6.2 Terrain Awareness and Warning System Altitude Callouts

The Airbus A300 FWC is equipped with an automated aural "minimums" alert that would have sounded at 0447:14, about 3 seconds after the captain said "two miles." However, UPS had not activated the alert. Further, Airbus A300 airplanes can issue altitude callout alerts through the airplane's FWC. Rather than the 500-ft callout, many Airbus A300 operators use the 400-ft callout generated within the FWC. Additionally, TSO-151C requires the TAWS to provide a 500-ft callout when descending within 500 ft above terrain or the nearest runway elevation. However, it does not require operators to enable the 500-ft callout feature. Neither the 500-ft TAWS callout (through the EGPWS) nor the 400-ft callout (through the Airbus FWC) were activated on the accident airplane; therefore, these callouts did not occur when the airplane neared the terrain.

Although the PM is responsible for making altitude callouts, the NTSB concludes that an automated "minimums" and/or altitude above terrain alert would have potentially provided the flight crewmembers with additional situational awareness upon their arrival at the minimum descent altitude and made them aware that their continued descent would take them below the minimum descent altitude. Additionally, in the absence of the automated "minimums" alert, either the EGPWS 500-ft callout or the Airbus 400-ft callout could have made the flight crewmembers aware of their proximity to the ground, and they could have taken action to arrest the descent. Therefore, the NTSB recommends that the FAA require all operators of airplanes equipped with the automated "minimums" alert to activate it. Furthermore, for those airplanes not equipped with an automated "minimums" alert, the NTSB recommends that the FAA require all operators of airplanes equipped with TAWS to activate the TAWS 500-ft voice callout or similar alert.

2.6.3 Flight Management System/Flight Management Computer

According to UPS check airmen, all approaches (precision and nonprecision) must be sequenced in the FMC. The process of sequencing approaches ensures that there are no undesired navigation legs remaining in the FMC that could result in flight plan discontinuities and provides pilots with additional awareness of the airplane's position relative to the approach path. When the Profile Final Approach mode ("profile mode") is used to fly a nonprecision approach, sequencing the FMC is even more critical because, otherwise, the FMC-generated glidepath might not be correct (as in this accident).

The A300 profile approach is an implementation of the CDFA technique. The profile approach uses the airplane's FMC to compute a desired profile glidepath extending from a point above the runway threshold back along the approach course and displays the airplane's vertical deviation from this glidepath to the pilot using the VDI on the ND.[113] The profile approach allows nonprecision approaches to be flown in a manner similar to the more familiar ILS approach, which provides vertical guidance via a glideslope signal.

By not properly sequencing the approach and leaving the original navigation path direct to KBHM in the FMC, a flight plan discontinuity was introduced that prevented the autopilot from engaging in profile mode, even though the 3.28˚ glidepath was programmed into the FMC and the profile mode was armed.[114] Further, and in spite of the flight plan discontinuity, the FMC constructed a glidepath for the approach using the 3.28˚ angle and the total length of all the navigation legs in the FMC, including the improper direct-to-KBHM leg. Because this length was

[113] For an ILS approach, lateral course correction information is provided by the localizer deviation diamond, and the primary source for vertical path correction information is the glideslope diamond.

[114] This sequence of events was confirmed by information downloaded from the FMC and by simulator testing.

unrealistically long, the altitude of the glidepath was unrealistically high for the airplane's actual distance from the runway, rendering the glidepath meaningless.

The flight crew should have been familiar with the process for sequencing the FMC for the localizer runway 18 approach because it is a common practice in training and necessary for any approach to be properly setup in the FMC. The NTSB found, however, that this essential task is not described in any FAA-approved or -accepted manual at UPS and is only described in the UPS PTG. The NTSB believes that fundamental procedures like sequencing the FMC are more likely to be standardized and retained by pilots if contained in FAA-approved or -accepted manuals like the AOM, which are subject to the manual review oversight process defined in FAA Order 8900.1, Flight Standards Information Management System. Including this information in documents reviewed by the FAA also means that pilots can be evaluated on their knowledge of the material.

In addition, the Profile Briefing Guide used by the captain to initially brief the approach did not contain guidance indicating that the FMC flight plan had to be properly sequenced for the autopilot to capture the FMC-generated glidepath or to ensure that the FMC-generated glidepath was correct. It is imperative that flight crews properly enter and sequence the flight plan information accurately, and correct and consistent flight crew guidance is an important tool for reinforcing the criticality of the sequencing step.

Although the flight crew configured the FMC for an approach on every flight and should have been familiar with the procedure, the NTSB concludes that consistent training in and FAA oversight and evaluation of fundamental procedures necessary to conduct an approach, such as sequencing the FMC, are critical to flight safety. Therefore, the NTSB recommends that the FAA require POIs of 14 CFR Part 121, 135, and 91 subpart K operators to verify that procedures critical to approach setup, like configuring an approach in the FMC for those approaches dependent on that step, are included in FAA-approved or -accepted manuals.

While on final approach, particularly in IMC, it is imperative that pilots vigilantly monitor the flight instruments to ensure that the airplane remains on course and on speed and so that any deviation from the desired lateral and vertical paths can be corrected promptly. For a localizer approach flown in profile mode, the primary source for lateral course correction information is the localizer deviation diamond, and the primary source for vertical path correction information is the VDI on the ND.

From the time that the first officer activated the final approach, the VDI diamond was pegged at the top of its scale, indicating that the airplane was at least 200 ft below the glidepath constructed by the FMC. When the airplane was at 2,500 ft msl and still more than 1 nm from BASKN, this would be the expected VDI indication because the (correct) glidepath would indeed be more than 200 ft above the airplane. However, within 1 nm of BASKN, the pilots should have expected that the VDI diamond would start to move down toward the center of the scale, as the airplane intercepted the glidepath from below. On the accident flight, however, the VDI would have remained pegged at the top of the scale even as the airplane passed BASKN. At BASKN, the pilots were very aware that they were above, not below, the desired glidepath, but neither seemed to comment about the VDI indication.

It is not known whether either pilot ever looked at the VDI throughout the approach, including when they were discussing the airplane being high at 0446:54. It is also unknown what information the pilots were using to conclude that the airplane was high at that time, when the primary source of such information (the VDI) would have indicated that it was at least 200 ft low.[115]

If the captain realized that the VDI was unusable but decided to proceed with the approach anyway, he would have had to revert from a CDFA-type approach to a “dive and drive” technique, relying on the step-down altitudes for vertical guidance. Consistent with an awareness of the step-down altitudes, at 0446:46.8, while descending through 1,920 ft msl (1,390 ft agl), the captain stated, “alright so at three point three should be at thirteen eighty,” referencing the minimum crossing altitude at IMTOY at 1,380 ft msl. The airplane crossed IMTOY very close to this altitude, at which point it intersected the proper glidepath; however, the captain did not decrease the rate of descent, and the airplane passed through the glidepath descending at 1,500 fpm. Further, the captain did not arrest the rate of descent as the airplane approached and then descended through the minimum descent altitude of 1,200 ft, even though he had commented that “DA [decision altitude] is twelve hundred” only about 11 seconds earlier, when the airplane was descending through 1,470 ft. The captain’s failure to decrease the rate of descent at IMTOY and to completely arrest it at the minimum descent altitude is inconsistent with his evident awareness of the minimum crossing altitude at IMTOY (1,380 ft) and the decision altitude (1,200 ft). Thus, if the captain indeed planned to conduct a “dive and drive” approach after BASKN, he did not do so properly once he reached IMTOY.

It is also possible that both pilots misinterpreted the VDI indication even though it should have been very familiar to them since it was identical to an ILS glideslope indication. The captain’s comment at 0446:53.7 that “we’re like way high … or higher” directly contradicted the information that would have been displayed on the VDI unless he was misinterpreting it. Similarly, the first officer’s response (“about … a couple hundred feet … yeah”) confirmed the captain’s statement but was also inconsistent with the VDI display.[116] Nonetheless, if the pilots knew that they were 200 ft above the desired glidepath at BASKN and then observed the VDI pegged at the top of the scale, they may have associated that indication with the airplane being above the desired path, even though the opposite was true. Once this misinterpretation was made, the persistent full-scale deflection of the VDI could have convinced both pilots that the airplane was quite high throughout the descent from BASKN. Such confusion could explain why the captain maintained a very large rate of descent (1,500 fpm) for such a long time (he may have been expecting to see the VDI diamond move as he descended to intercept the glidepath from above) and why he stated “we’re like way high...or higher” at 04:46:53.7. The “or higher” part of this phrase suggests that the captain was not sure exactly how high the airplane was, only that the airplane was very high, as would be the case if he were reversing the meaning of the full-scale deflection of the VDI.

As described above, the VDI was displaying meaningless information because the flight crew did not verify that the flight plan was sequenced in the FMC. If the pilots had observed the VDI at BASKN and correctly interpreted it as indicating that the airplane was more than 200 ft

[115] Analysis of the FDR indicates that at 0446:54, the airplane was in fact about 145 ft above the FMC-generated glidepath to the runway.

[116] Full-scale deflection of the VDI corresponds to being 200 ft from the desired glidepath, so it is possible that the first officer, too, referenced the VDI and reversed its meaning when responding that they were a couple hundred feet high.

below the glidepath (when at BASKN, the flight crew was aware that the airplane's position was actually above the glidepath), they should have been alerted to the improper sequencing of the FMC flight plan. While the VDI is a critical and primary part of the instrument scan when conducting a profile mode approach, secondary indications also could have alerted them to the improper sequencing, including the vertical deviation readout on the CDU takeoff/approach page, KBHM being identified as the next approach fix, the extra line direct to KBHM on the ND, and the F-PLN DISCONTINUITY indication on the CDU flight plan page.

Aside from the meaningless VDI indication (and the failure of the autopilot to engage in profile mode), there were several cues in the pilots' primary instrument scans that would have alerted them that the FMC was improperly sequenced. On the contrary, as stated earlier, the crew may have believed that the sequencing was proper because (1) the localizer was captured, (2) the airplane icon was positioned on the localizer on the NAV display, and (3) the first officer was able to activate the approach to runway 18 in the FMC. Hence, the flight crew may have followed cues that supported their expectation of a properly sequenced approach and ignored those that did not support that expectation.

As noted previously, the VDI provides vertical guidance for a profile approach in the same way that glideslope provides vertical guidance for an ILS approach, but there was no VDI indication to the flight crew that would indicate the display was based on meaningless information. Throughout the approach, the VDI indicated that the airplane was low, not high. If the crew observed and correctly interpreted the VDI, they would have believed that the VDI was instructing them to climb, not descend. Nonetheless, the presence of the meaningless VDI indication may have obscured the fact that the FMC was not sequenced correctly. The NTSB concludes that a VDI constructed from information known to be anomalous (for example, containing a flightpath discontinuity) could be confusing to flight crews. Therefore, the NTSB recommends that Airbus develop and implement, for applicable Airbus models, means of providing pilots with a direct and conspicuous cue when they program the FMC flight plan incorrectly such that it contains such elements as improper waypoints or discontinuities that would allow the VDI to present misleading information for an approach. Additionally, the NTSB recommends that the FAA work with industry, for all applicable aircraft, to develop and implement means of providing pilots with a direct and conspicuous cue when they program the FMC flight plan incorrectly such that it contains such elements as improper waypoints or discontinuities that would allow the VDI to present misleading information for an approach.

3. Conclusions

3.1 Findings

1. The pilots were properly certificated, qualified, and trained for the 14 *Code of Federal Regulations* Part 121 flight in accordance with Federal Aviation Administration regulations. No evidence was found indicating that the flight crew's performance was affected by any behavioral or medical condition or by alcohol or drugs.

2. The accident airplane was loaded within weight and center of gravity limits and was equipped, certificated, and maintained in accordance with Federal Aviation Administration regulations and the manufacturer's recommended maintenance program. Postaccident examination found no evidence of any preimpact structural, engine, or system failure or anomaly.

3. Although the activation of the crash phone was delayed, the aircraft rescue and firefighting (ARFF) response proceeded rapidly, and ARFF operations began in a timely manner.

4. The dispatcher of UPS flight 1354 should have alerted the flight crew to the limited options for arrival at Birmingham-Shuttlesworth International Airport (BHM), especially that runway 18 was the only available runway, because doing so would have further helped the pilots prepare for the approach to BHM and evaluate all available options.

5. The captain, as pilot flying, should have called for the first officer's verification of the flight plan in the flight management computer (FMC), and the first officer, as pilot monitoring, should have verified the flight plan in the FMC; their conversation regarding nonpertinent operational issues distracted them from recognizing that the FMC was not resequenced even though several salient cues were available.

6. The captain's change to a vertical speed approach after failing to capture the profile glidepath was not in accordance with UPS procedures and guidance and decreased the time available for the first officer to perform her duties.

7. The flight crew did not monitor the descent rate and continued to fly the airplane with a vertical descent rate of 1,500 ft per minute below 1,000 ft above ground level, which was contrary to standard operating procedures, resulting in an unstabilized approach that should have necessitated a go-around.

8. The flight crew did not sufficiently monitor the airplane's altitude during the approach and subsequently allowed the airplane to descend below the minimum altitude without having the runway environment in sight.

9. The first officer's failure to make the "approaching minimums" and "minimums" altitude callouts during the approach likely resulted from the time compression resulting from the excessive descent rate, her momentary distraction from her pilot monitoring duties by looking out the window when her primary responsibility was to monitor the instruments, and her fatigue.

10. Although it was the first officer's responsibility to announce the callouts as the airplane descended, the captain was also responsible for managing the approach in its final stages using a divided visual scan that would not leave him solely dependent on the first officer's callouts to stop the descent at the minimum descent altitude.

11. The captain's belief that they were high on the approach and his distraction from his pilot flying duties by looking out the window likely contributed to his failure to adequately monitor the approach.

12. For the captain, fatigue due to circadian factors may have been present at the time of the accident.

13. The captain's poor performance during the accident flight was consistent with past performance deficiencies in flying nonprecision approaches noted during training; the errors that the captain made were likely the result of confusion over why the profile did not engage, his belief that the airplane was too high, and his lack of compliance with standard operating procedures.

14. The first officer poorly managed her off-duty time by not acquiring sufficient sleep, and she did not call in fatigued; she was fatigued due to acute sleep loss and circadian factors, which, when combined with the time compression and the change in approach modes, likely resulted in the multiple errors she made during the flight.

15. Given the increased likelihood of fatigue during overnight operations, briefing the threat of fatigue before every flight would give pilots the opportunity to identify the risks associated with fatigue and mitigate those risks before taking off and throughout the flight.

16. The schedule the flight crew was flying would have been in compliance with 14 *Code of Federal Regulations* Part 117 requirements had those requirements been in effect and applied to all-cargo operators.

17. The first officer did not adhere to the UPS fatigue policy; she could have called in fatigued for the accident flight if she were not fit for duty and been immediately removed from duty until she felt fit to fly again.

18. By providing fatigue counseling, UPS and the Independent Pilots Association would help to increase pilot awareness and understanding about fatigue and may provide a valuable resource in understanding fatigue calls.

19. A joint dispatcher/pilot training module, specific to crew resource management and dispatcher resource management principles, would facilitate improved communication between pilots and dispatchers and enhance their understanding of the challenges and capabilities of the pilot/dispatcher roles in the safe operation of the flight.

20. By not rebriefing or abandoning the approach when the airplane did not capture the profile glidepath after passing the final approach fix, the flight crewmembers placed themselves in an unsafe situation because they had different expectations of how the approach would be flown.

21. The captain's moderate response to the enhanced ground proximity warning system "sink rate" caution alert (adjusting the flight's vertical speed) was consistent with aircraft operating manual guidance and training; however, the response was not sufficient to prevent striking the trees on the approach and was not consistent with the more conservative guidance in the pilot training guide.

22. The continuous descent final approach technique provides a safer alternative to "dive and drive" during nonprecision approaches.

23. If operators identified and implemented ways for pilots to receive more opportunities to maintain proficiency in nonprecision approaches, pilots could conduct such approaches more safely.

24. Due to the importance of pertinent remarks, such as variable cloud ceilings, to the flight crew's understanding of weather conditions, it is critical that flight dispatch papers, the aircraft communication addressing and reporting system, and automatic terminal information service contain pertinent remarks for weather observations because such remarks provide flight crews a means to understand changing weather conditions. Had the flight crew been provided with the pertinent remarks in this accident, they may have been aware of the possibility of changing visibility and ceilings upon their arrival at Birmingham-Shuttlesworth International Airport.

25. The newer enhanced ground proximity warning system software, part number 965-0976-003-218-218 or later, will provide an advanced alert and significantly improve safety margins, although its effect on the outcome of this accident is unknown because it cannot be determined how aggressively the pilots would have responded to an earlier "too low terrain" alert.

26. An escalating series of terrain awareness and warning system (TAWS) alerts before impact with terrain or obstacles is not always guaranteed due to technological limitations, which reduces the safety effectiveness of the TAWS during the approach to landing.

27. An automated "minimums" and/or altitude above terrain alert would have potentially provided the flight crewmembers with additional situational awareness upon their arrival at the minimum descent altitude and made them aware that their continued descent would take them below the minimum descent altitude.

28. In the absence of the automated "minimums" alert, either the enhanced ground proximity warning system 500-ft callout or the Airbus 400-ft callout could have made the flight crewmembers aware of their proximity to the ground, and they could have taken action to arrest the descent.

29. Consistent training in and Federal Aviation Administration oversight and evaluation of fundamental procedures necessary to conduct an approach, such as sequencing the flight management computer, are critical to flight safety.

30. A vertical deviation indicator constructed from information known to be anomalous (for example, containing a flightpath discontinuity) could be confusing to flight crews.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the flight crew's continuation of an unstabilized approach and their failure to monitor the aircraft's altitude during the approach, which led to an inadvertent descent below the minimum approach altitude and subsequently into terrain. Contributing to the accident were (1) the flight crew's failure to properly configure and verify the flight management computer for the profile approach; (2) the captain's failure to communicate his intentions to the first officer once it became apparent the vertical profile was not captured; (3) the flight crew's expectation that they would break out of the clouds at 1,000 feet above ground level due to incomplete weather information; (4) the first officer's failure to make the required minimums callouts; (5) the captain's performance deficiencies likely due to factors including, but not limited to, fatigue, distraction, or confusion, consistent with performance deficiencies exhibited during training; and (6) the first officer's fatigue due to acute sleep loss resulting from her ineffective off-duty time management and circadian factors.

4. Recommendations

4.1 New Recommendations

As a result of this investigation, the National Transportation Safety Board makes the following new safety recommendations:

To the Federal Aviation Administration:

Require principal operations inspectors to ensure that operators with flight crews performing 14 *Code of Federal Regulations* Part 121, 135, and 91 subpart K overnight operations brief the threat of fatigue before each departure, particularly those occurring during the window of circadian low. (A-14-72)

Require operators to develop an annual recurrent dispatcher resource management module for dispatchers that includes participation of pilots to reinforce the need for open communication. (A-14-73)

Require principal operations inspectors to work with operators to ensure that their operating procedures explicitly state that any changes to an approach after the completion of the approach briefing should be rebriefed by the flight crewmembers so that they have a common expectation of the approach to be conducted. (A-14-74)

Require principal operations inspectors to ensure consistency among their operators' training documents, their operators' Federal Aviation Administration-approved and -accepted documents, such as the aircraft operating manual, and manufacturers' guidance related to terrain awareness and warning system caution and warning alert responses, and ensure that responses are used during night and/or instrument meteorological conditions that maximize safety. (A-14-75)

Require principal operations inspectors of 14 *Code of Federal Regulations* Part 121, 135, and 91 subpart K operators to ensure that Federal Aviation Administration-approved nonprecision instrument approach landing procedures prohibit "dive and drive" as defined in Advisory Circular 120-108. (A-14-76) (Supersedes Safety Recommendation A-06-8)

Require that the remarks section of meteorological aerodrome reports be provided to all dispatchers and pilots in flight dispatcher papers and through the aircraft communication addressing and reporting system. (A-14-77)

Expand the current guidance available in Federal Aviation Administration Order 7110.65, "Air Traffic Control," to further define meteorological aerodrome report pertinent remarks. (A-14-78)

Issue a safety advisory bulletin to air traffic controllers providing examples of the types of meteorological aerodrome report remarks information considered pertinent and reminding them of the requirement to add such pertinent remarks to automatic terminal information service broadcasts. (A-14-79)

Issue a special airworthiness information bulletin to notify operators about the circumstances of this accident and the potential safety improvements related to the Honeywell enhanced ground proximity warning system part number 965 0976-003-218-218 or later software update. (A-14-80)

Advise operators of aircraft equipped with terrain awareness and warning systems (TAWS) of the circumstances of this accident, including that, in certain situations, an escalating series of TAWS warnings may not occur before impact with terrain or obstacles. Encourage operators to review their procedures for responding to alerts on final approach to ensure that these procedures are sufficient to enable pilots to avoid impact with terrain or obstacles in such situations. (A-14-81)

Revise the minimum operational performance standards to improve the effectiveness of terrain awareness and warning systems when an airplane is configured for landing and near the airport, including when the airplane is descending at a high rate and there is rising terrain near the airport. (A-14-82)

Require all operators of airplanes equipped with the automated "minimums" alert to activate it. (A-14-83)

For those airplanes not equipped with an automated "minimums" alert, require all operators of airplanes equipped with terrain awareness and warning systems (TAWS) to activate the TAWS 500-ft voice callout or similar alert. (A-14-84)

Require principal operations inspectors of 14 *Code of Federal Regulations* Part 121, 135, and 91 subpart K operators to verify that procedures critical to approach setup, like configuring an approach in the flight management computer for those approaches dependent on that step, are included in Federal Aviation Administration-approved or -accepted manuals. (A-14-85)

Work with industry, for all applicable aircraft, to develop and implement means of providing pilots with a direct and conspicuous cue when they program the flight management computer flight plan incorrectly such that it contains such elements as improper waypoints or discontinuities that would allow the vertical deviation indicator to present misleading information for an approach. (A-14-86)

To UPS:

Work with the Independent Pilots Association to conduct an independent review of the fatigue event reporting system to determine the program's effectiveness as a nonpunitive mechanism to identify and effectively address the reported fatigue issues. Based on the findings, implement changes to enhance the safety effectiveness of the program. (A-14-87)

Work with the Independent Pilots Association to counsel pilots who call in fatigued and whose sick bank is debited to understand why the fatigue call was made and how to prevent it from recurring. (A-14-88)

To the Independent Pilots Association:

Work with UPS to conduct an independent review of the fatigue event reporting system to determine the program's effectiveness as a nonpunitive mechanism to identify and effectively address the reported fatigue issues. Based on the findings, implement changes to enhance the safety effectiveness of the program. (A-14-89)

Work with UPS to counsel pilots who call in fatigued and whose sick bank is debited to understand why the fatigue call was made and how to prevent it from recurring. (A-14-90)

To Airbus:

Develop and implement, for applicable Airbus models, means of providing pilots with a direct and conspicuous cue when they program the flight management computer flight plan incorrectly such that it contains such elements as improper waypoints or discontinuities that would allow the vertical deviation indicator to present misleading information for an approach. (A-14-91)

4.2 Previous Recommendations Reclassified in This Report

One recommendation to the Federal Aviation Administration is reclassified "Closed—Unacceptable Action/Superseded."

Require all 14 CFR Part 121 and 135 operators to incorporate the constant-angle-of-descent technique into nonprecision approach procedures and to emphasize the preference for that technique where practicable. (A-06-8)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

CHRISTOPHER A. HART
Acting Chairman

ROBERT L. SUMWALT
Member

MARK R. ROSEKIND
Member

EARL F. WEENER
Member

Adopted: September 9, 2014

Members Sumwalt, Rosekind, and Weener filed the following statements.

Board Member Statements

Member Robert L. Sumwalt filed the following concurring statement on September 18, 2014.

Fatigue and Part 117

Going into the Board Meeting, there was much outside speculation about the role that fatigue may have played in the accident. The UPS pilots union, the Independent Pilots Association, called for an end of the cargo carve-out (known as Part 117), where cargo airline pilots are excluded from the more stringent flight and duty time regulations imposed earlier this year for passenger airlines.

To be clear, NTSB has gone on record opposing the cargo carve-out. On July 29, 2013, just two weeks before the UPS 1354 crash, NTSB wrote to FAA Administrator Huerta, stating: "The NTSB disagrees with this exclusion, as many of the fatigue-related accidents that we have investigated over the years involved cargo operators. We also believe that, because of the time of day that cargo operations typically occur, such operations are in greater need of these requirements." The letter stated that the NTSB is "very concerned about the cargo exclusion."

That concern aside, the facts are clear that the accident crew's schedule was far more conservative than those contained in Part 117. To use an accident to make a point when the facts surrounding the accident don't support that point – is not simply an illogical conclusion, but also one that must be viewed as purely politically motivated. The NTSB will not sacrifice our credibility by making illogical conclusions or those that are politically motivated.

Before the Board Meeting and even after, there have been comments reported in various media sources, where some have purported that the accident pilots "told us on the CVR that they were fatigued." Indeed, there was a conversation recorded by the CVR about the Part 117 carve-out, beginning at 03:41:58.0 and ending at 03:43:30.9. However, after listening to the CVR, I equated this conversation to many I heard in my 24-year airline pilot career, where pilots complained of working conditions. Oftentimes it is just that – complaining and making conversation. Although the first officer did state that when she woke up in the sleep room an hour earlier, she was "so tired," I suspect that anyone who wakes up at that time of day would initially suffer from sleep inertia and feel groggy. It is not, as reports have portrayed it, as some eerie statement from the crew, ominously signaling that, in case of a crash, they wanted the world to know they were tired.

Testimony received at the NTSB's investigative hearing for this accident, and party submissions from IPA and UPS, revealed cavernous gaps between how the company and its pilots viewed the company's fatigue policies. Further evidence of these differences was exhibited by a survey of UPS pilots conducted by IPA in March 2014. That survey yielded 2,202 responses – a return rate of 92.59 percent of UPS pilots. All surveys have biases, and there is no reason to believe this one is an exception. However, when such a high number of responses are so highly skewed in one direction, it is reasonable to believe that there is some truth to what is being reported; it is doubtful that such a large number of respondents would collude or exaggerate their responses in the same way.

The consistency and number of responses to this survey as it relates to fatigue are striking. For example, consider the survey statement: "Calling in fatigued will invite adverse scrutiny from UPS." Eight-eight percent of the respondents answered this as either "strongly agree" (58%) or "somewhat agree" (30%). Another statement, "The UPS culture encourages you to call in fatigued when you are fatigued," yielded 91% of the survey respondents replying either "strongly disagree" (68%) or "somewhat disagree" (23%).

These answers and others on the survey, as well as testimony during the investigative hearing, should be a stark wake-up call to UPS. However, UPS management remains defiant. At the conclusion of the board meeting where I expressed concern over the results of this survey, UPS representatives were quick to approach me and deny these problems exist. Denial is the enemy of change. Rather than trying to convince others that an estranged culture does not exist, UPS and its pilots would be better served by working to improve the working conditions. That's why the Board issued recommendations to UPS and IPA to work together on fatigue reporting. It's quite indicative of a poor working relationship when it takes an NTSB recommendation to get two groups to engage in constructive dialogue on such an important topic.

EGPWS Software and Auto-callouts

The report states that, had the aircraft's EGPWS software been updated by the company, a "too low terrain" caution alert would have sounded 6.5 seconds earlier and 150 feet higher than the EGPWS alert the flight crew received. That said, due to the airplane's excessive descent rate, and because it could not be conclusively determined if the pilots would have responded within 2.5 seconds, the investigation was unable to determine whether these software enhancements would have prevented the accident. Although it cannot be said for certain that these upgrades would have *prevented* the crash, I can say for certain that it would have provided the crew with a greater *opportunity* for avoiding the crash.

Numerous industry publications, including information presented at Airbus safety conferences, have emphasized the importance of maintaining up-to-date terrain databases and software. These software upgrades are offered free of charge. It is therefore incomprehensible that a company such as UPS would not upgrade this critically important software.

Another safety enhancement that UPS did not take advantage of was activating auto-callouts, also known as "smart callouts." With smart callouts, equipment on the airplane announces altitudes as the aircraft descends. Industry best practices call for operators to activate smart callouts. For example, Flight Safety Foundation's seminal document on CFIT accidents[1] states that "operators should … activate smart callouts at 2,500 feet, 1,000 feet, 500 feet, at the altitude set in the decision height (DH) window and at 50 feet, 40 feet, 30 feet, 20 feet, and 10 feet for better crew terrain awareness."

The Board unanimously approved a finding that had these callouts been activated, "it would have made the crew aware of their close proximity to the ground and they could have taken action to arrest the descent."

[1] Flight Safety Foundation, Killers in Aviation: FSF Task Force Facts About Approach and Landing and Controlled Flight Into Terrain Accidents (1999). *Flight Safety Digest, 17*(11-12). Retrieved from http://flightsafety.org/fsd/fsd_nov-feb99.pdf.

Oddly, although other aircraft in the UPS fleet have these smart callouts, UPS did not activate smart callouts on their A-300 fleet, despite industry recommendations that they be used. As in the case of EGPWS software upgrades, had the smart callouts been activated, valuable life-saving cues would have been presented to the crew, possibly preventing the crash.

I hope this crash can serve as an important reminder of the need for operators to provide these critical safety enhancements.

Interruptions and Distractions

While there were several errors involving this flight, I believe there were two critical errors committed by the crew. The first was failure to properly sequence the flight plan, which compromised the ability to conduct a profile approach. However, even with this error, the crew could have safely conducted a raw data localizer approach.

I kept asking myself how a flightcrew could miss something as basic as sequencing the flight plan – something that is done on nearly each and every flight. My final audition of the CVR provided me, as a former airline pilot who flew Airbus aircraft myself, with an “ah-ha moment,” to help me understand how that error likely occurred.

When the crew was directed by ATC to turn 10 degrees right and intercept the localizer, that would be the point where a crew would typically sequence the flight plan to extend the centerline of the runway. In this case, however, the first officer initiated a few lighthearted comments, joined by the captain, pertaining to runway 18 being the only available alternative for landing.

F/O: “I don’t think we have many choices if runway 6 is closed” [laughter]
Captain: “Ahhh [laughter] I know. What else can we do” [laughing].
F/O: “I’m like, ahhh, well, what else ahh you gonna – unroll another one out there for us real quick or whatever” [chucking]
Captain: “It’s like, okay, yeah, you got another… yeah you got an ILS on some’m else?” [chuckling]
F/O: “Uhh… I know” [chuckling]

Although not a violation of the sterile cockpit rule, because the flight was about 10,000 feet msl, I believe it did interrupt the typical flow of actions on the flight deck. Research on interruptions and distractions has shown that a return to an intended task is often missed when faced with an interruption. I recognize that it is important to be comfortable in the cockpit, and FAA guidance on CRM states that that the tone in the cockpit should be “friendly, relaxed, and supportive.” But it also points out that the crew must ensure that cockpit discipline is maintained, crew vigilance is not reduced and critical items are not missed. And on this flight, critical items were missed.

Many years ago, then-NTSB Board Member John Lauber put this in perspective: “There is a fine line separating a relaxed and easy atmosphere in a cockpit from a lax one where distractions can result in critical failures. Professionalism may be described as knowing the difference between the two.” There is a time and a place to be lighthearted and there is a time and place to set all else aside and focus on the task at hand.

Even missing the sequencing of the flight plan, the approach still should have been able to be flown safely using only the raw data from the localizer beam and adhering to step-down fixes, or the approach could have been abandoned once things didn't look right.

Unfortunately, those opportunities were missed.

The second critical error, in my opinion, was failure to monitor altitude during the approach, and this failure led to the CFIT. As such, the Board identified this error as one that was causal to the crash. Even with weather reports that may have set an expectation for a less demanding approach due to reported weather conditions; even with the crew not properly sequencing the flight plan in the FMS; even with the captain not verbalizing his intentions after not capturing the profile; even with the captain exceeding stabilized approach parameters and not executing a missed approach; and, even with an first officer who was fatigued, the crash would not have occurred if the crew had monitored altitude and not allowed the aircraft to descend below the minimum altitude unless the runway was in sight.

One question that cannot be answered with absolute certainty is how the crew missed the indication on the VDI that clearly showed that they were *below* the desired glidepath – not *above it*, as the captain apparently was convinced. We can never know for certain, but I believe it is plausible that the captain had a mindset that he was high, and because of that strong belief, he disregarded all information that contradicted that belief. In other words, he could have had "tunnel vision" in which the need to descend may have prompted him to disregard altitude, vertical speed, and VDI indications. The below comments from the CVR support the notion that he was focused on being high:

Time before first impact	Captain's comments
12 min, 30 sec	They're generous today. Usually they kind'a take you to fifteen and they hold you up high.
4 min, 36 sec.	And they keep you high.
4 min, 35 sec.	Eh, I know. It's unbelievable.
4 min, 23 sec.	Divin' for the airport. Unbelievable.
2 min, 43 sec.	Unbelievable.
1 min, 14 sec.	Unbelievable. Kept us high.
1 min, 8 sec.	Yeah, I'm gonna do vertical speed. Yeah, he kept us high.
39 sec	And we're like way high…
36 sec	…or higher

From the captain's comments, it is clear that he believed he was high. As the report mentions, the crew likely had the expectation that, because of the reported weather, they would break out of the clouds at 1,000 feet above ground and see the runway right in front of them. It is plausible that the captain's tunnel vision that he was high, combined with the false expectation they would break out of the clouds at 1,000 feet, allowed him to have reduced attention to altitude awareness.

A plaque at the NTSB's training center states, "From tragedy we draw knowledge to improve the safety of us all." I sincerely hope that knowledge will be gained from this tragedy, and the involved organizations will work cooperatively to move forward, so that others don’t have to endure the pain suffered by the families and friends of the crew of UPS flight 1354.

Member Mark R. Rosekind filed the following concurring statement on September 16, 2014.

> "*The captain's colleagues indicated that, in the weeks before the accident, [he] had expressed concern that the flying schedules were becoming more demanding. He further stated that flying 1 week on then 1 week off made it difficult to get back into a routine the first couple of days of a trip and that the end of the trip was also difficult. He told one colleague, 'I can't do this until I retire because it's killing me.*'" – Report Section 1.5.1 The Captain

Tragically, the captain's words here are prophetic, as fatigue was one of the factors that contributed to this accident and his death. The lives lost in the crash of UPS Flight 1354 herald the fact that, while aviation has made tremendous strides to address fatigue in flight operations, it has much further to go.

I commend NTSB investigators and staff for preparing an excellent report that provides a thorough and accurate analysis of fatigue's pivotal role in the events causing this accident. It is only through a precise and complete understanding of how sleep loss and circadian factors affected the crew's management of the landing approach that we can help avoid incidents like this in the future, see where the related safety gaps are in aviation, and apply what we have learned to safety across all transportation modes.

This begins with acknowledging the effects on human performance that result from fatigue through multiple sources; in this accident it was sleep loss AND/OR circadian disruption. The presence of either or both while flying an aircraft can degrade skills and compromise safety with deadly results as the catastrophic outcome of Flight 1354 attests. Circadian factors affected both the captain and first officer, with the first officer suffering from additional sleep-related fatigue as well. Recommendations approved by the Board on September 9th represent significant innovation and real progress in the NTSB's approach to combating fatigue. Three, in particular, have far-reaching implications.

First, by requiring flight crews assigned to overnight operations to brief about the threat of fatigue before departure, particularly those crews scheduled to fly during the window of circadian low; the NTSB goes beyond a recommendation that simply addresses the safety risks presented by sleep loss alone. It acknowledges the scientifically proven fact that all humans are biologically affected by the deep physiological trough in the daily cycle that routinely occurs during overnight operations with known safety risks. Flight crews must understand and take actions to mitigate the adverse effects on human performance. Briefing the specific threats and strategic countermeasures beforehand is critical, and represents a great step forward in aviation fatigue management.

Unfortunately, even though the FAA's new pilot fatigue rules promulgated earlier this year do not apply to cargo pilots; these would not have influenced the outcome of Flight 1354 even if they had been followed. This places added emphasis on the report's treatment of fatigue and the need for great accuracy and thoroughness. The report does an excellent job describing the analysis of this issue and addressing it directly in the findings.

Second, the recommendation to UPS and the Independent Pilots Association (IPA) to collaborate on a program to counsel pilots who call in fatigued and whose sick bank is debited represents another innovation to fatigue management in aviation providing an important opportunity to address individual knowledge and actions. The concept of shared responsibility reflected in making the recommendation complementary to both UPS and IPA is an important model to highlight. It emphasizes the need to understand why a pilot calls in fatigued and how that condition may be prevented from recurring.

Third, counseling on fatigue calls only works well if the program is carefully reviewed and evaluated. The recommendation to UPS and IPA to conduct an independent review of the fatigue event reporting system to determine its efficacy in identifying and addressing the reported fatigue issues will help ensure they are providing the highest level of safety. Based on the findings of an independent review and implementing any changes to enhance effectiveness, these programs can provide an invaluable early warning system to confront fatigue issues before they result in accidents and incidents.

For more than 45 years, NTSB investigations have found that fatigue either caused or contributed to accidents in all transportation modes and the agency has issued over 200 safety recommendations addressing diverse areas such as hours of service regulations, scheduling policies, education and training, diagnosis and treatment of sleep disorders, research, and vehicle technologies. I am pleased the Board unanimously approved the recommendations arising from the crash of 1354 to advance the NTSB's efforts on fatigue, call attention to what remains to be done, and help provide everyone who flies – even in the quiet darkness of night – the safest skies possible.

Acting Chairman Hart and Members Sumwalt and Weener joined in this statement.

Member Earl F. Weener filed the following concurring statement on September 17, 2014.

The final report, and particularly the statement of probable cause, concerning the UPS Flight 1354 accident were thoughtfully deliberated and determined, and have my full support. I believe, though, there is a fundamental message from this accident worth emphasizing: the importance of personal responsibility, particularly in terms of making choices affecting fitness for duty.

As documented in the final report, this flight occurred during a time of day when the likelihood of performance decrements increases due to a dip in the circadian rhythm. However, the research findings on fatigue and its effects on human performance, specifically with regard to pilot operations, has led to the development of various mitigation strategies which, generally, include providing education, adjusting operations schedules, and putting in place fatigue risk management plans (now a statutory requirement) which include fatigue countermeasures. Fatigue countermeasures are an important factor in this strategy in order to offset the risks of fatigue impairing performance, and provide the fundamental underpinnings for allowing operations with inherently higher levels of risk to be conducted with acceptable levels of risk, such as those scheduled to take place during periods of circadian low. When implemented effectively, this approach has worked. As noted in the report, most operations occurring during a time period of circadian low do not result in accidents. However in this accident scenario, we have two pilots who, as the investigation documented, made very different choices – both in terms of their personal and professional lifestyle. The captain's decisions with regard to his time at work and at home reflect an awareness and effort to mitigate the risk of being fatigued on the job. In other words, he employed countermeasures, such as having adequate off-duty time for rest, exercising, controlled napping, and use of the company sleep rooms, to mitigate the risk and ensure he reported fit for duty. Alternatively, the same cannot be said of the first officer. In fact, the report documents a disturbing pre-accident history of fatigue inducing choices, both in her personal and professional life. Although the accident investigation was unable to determine whether fatigue affected the captain's performance, the effects of fatigue on the first officer's performance were conclusively determined. Fatigue countermeasures make a difference – they provide the underlying basis for enabling inherently risky activities to be undertaken in a safe and productive manner by mitigating the effects of fatigue and the likelihood of degradation in performance.

Fatigue risk management plans and countermeasures will be ineffective, though, if pilots fail to employ such mitigation strategies in their personal and professional lives. The bigger issue is fitness for duty – a more comprehensive concept requiring an evaluation of whether a pilot is both physiologically and mentally prepared to assume his or her duties. Fitness for duty is an individual, personal assessment to be undertaken by every pilot prior to every flight; it is not a single, periodic determination nor is it established by obtaining a medical certificate from a Federal Aviation Administration (FAA) aviation medical examiner. Fatigue is one of several important considerations, when making a fitness for duty determination. As the accident report illustrates, failure to make the appropriate determination can have deadly consequences. UPS recognized the importance of fatigue in determining fitness for duty by explicitly mentioning it in the introduction of its fitness for duty policy found in its Flight Operations Manual, and by providing explicit training on pilot responsibility in terms of rest and fitness for duty. Sadly, the first officer disregarded company policy as well as fatigue training by making poor choices both on and off duty. Worth noting from the accident report, the first officer maintained a 3.5-4 hour commute schedule from home to the UPS base at Louisville; with a typical need for 9+ hours of sleep per night, she failed to obtain adequate sleep in the days leading up to the accident flight; instead of taking advantage of numerous sleep opportunities during that time period, she engaged in PED usage and travel; rather than maintaining a nocturnal schedule in support of her current assignment, she chose to revert to a diurnal schedule during a 62-hour layover; after reporting to colleagues and relatives she was tired, she did not take advantage of company provided sleep opportunities, whether by taking a hotel in San Antonio or using a sleep room between flights; and after arriving to work on the evening of August 13, knowingly tired, she failed to inform the company or captain that she was tired and unfit for duty. The first officer made several decisions contributing to her fatigue and ultimately made the wrong decision in arriving to work not fit for duty.

In the interest of safety, although contrary to the FAA's interpretation, it is important to note fitness for duty is not limited to, or an alternative way of describing fatigue. Fatigue is one, but not the only factor that can affect performance; other factors can play a role as well. For example, recently the NTSB concluded a safety study, entitled *Drug Use Trends in Aviation: Assessing the Risk of Pilot Impairment*. Although the study was based on accident data primarily from General Aviation operations, it nonetheless documented a concerning upward trend in the use of both potentially impairing medications and illicit drugs by pilots, some of whom also held airline transport pilot certificates (15%). Additionally, the study suggested the performance impairing effects of one of the most commonly used ingredients in over-the-counter medicines, diphenhydramine, are not widely understood by pilots. Like fatigue, medication and drug use can impair performance, again illustrating the need for a fitness for duty determination before climbing into a cockpit. Fitness for duty, though, should not be viewed as a concept exclusive to pilots; a fitness for duty determination is equally applicable to any safety related transportation position, including the maintenance, dispatch, operations and air traffic control environments in aviation.

In sum, the National Transportation Safety Board can recommend actions to address fatigue, drug and alcohol usage, and more broadly, fitness for duty. The FAA can issue regulations to require drug and alcohol testing and fatigue management programs, all in an attempt to ensure fitness for duty. The airlines can develop and implement policies and programs to comply with regulations, promote fitness for duty, educate/train on fatigue mitigations and provide disincentives to drug and alcohol usage. But the bottom line is: fitness for duty comes down to personal assessment and decision-making. The UPS Flight 1354 accident permanently changed the lives of two families in a very tragic manner. To the aviation industry, as a whole, it is a poignant reminder: the choices we make, both on and off duty, can be a matter of life or death.

Acting Chairman Hart and Members Sumwalt and Rosekind joined in this statement.

5. Appendixes

Appendix A: Investigation and Public Hearing

Investigation

The National Transportation Safety Board was initially notified of this accident on August 14, 2013. The following investigative groups were formed: Operations, Human Performance, Air Traffic Control, Meteorology, Airports/Survival Factors, Airworthiness, Powerplants, Structures, Systems, Aircraft Performance, and Maintenance Records. Board Member Robert Sumwalt accompanied the team.

Parties to the investigation were the Federal Aviation Administration (FAA), UPS, Birmingham Airport Authority, Pratt & Whitney, National Air Traffic Controllers Association, Teamster Local Union 2727, and the Independent Pilots Association (IPA). In accordance with the provisions of Annex 13 to the Convention on International Civil Aviation, the Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile (BEA) appointed an accredited representative to participate in the investigation as the representative of the State of Design and Manufacture of the airframe. Airbus investigators participated in the investigation as technical advisors to the BEA.

Investigative Hearing

An investigative hearing was held on February 20, 2014, in Washington, D.C. Then-Chairman Deborah A.P. Hersman presided.

The subjects discussed at the investigative hearing included performance of nonprecision approaches, human factors issues as applicable to this accident, and dispatch procedures, including the limitations of dispatch-related software. Parties to the investigative hearing were the FAA, UPS, IPA, Airbus, and Transport Workers Union.

Appendix B: Cockpit Voice Recorder Transcript

Transcript of an L-3/Fairchild FA2100-1020 solid-state cockpit voice recorder[1], installed on an UPS Airbus A300-600 (N155UP), which crashed during approach at the Birmingham-Shuttlesworth International Airport (KBHM) in Birmingham, Alabama.

LEGEND

CAM	Cockpit area microphone voice or sound source
HOT	Flight crew audio panel voice or sound source
INT	Intercom sound source
RDO	Radio transmissions from N155UP
GND	Radio transmissions from Louisville ground controller
TWRSDF	Radio transmissions from Louisville airport tower controller
APRSDF	Radio transmissions from Louisville approach controller
CTRINDY	Radio transmissions from Indianapolis center controller
CTRMEM1	Radio transmissions from first Memphis center controller frequency
CTRMEM2	Radio transmissions from second Memphis center controller frequency
CTRATL1	Radio transmissions from first Atlanta center controller frequency
CTRATL2	Radio transmissions from second Atlanta center controller frequency
TWRBHM1	Radio transmissions from first Birmingham tower controller frequency
TWRBHM2	Radio transmissions from second Birmingham tower controller frequency
UPSRAMP	Radio transmissions from UPS ramp controller
VEH	Radio transmissions from a ground vehicle at Birmingham
AC	Radio transmissions from another aircraft
ATIS	Automated Terminal Information Service
EPGWS	Enhanced Ground Proximity Warning System
TCAS	Traffic Alert and Collision Avoidance System
WXRADAR	Weather Radar
-1	Voice identified as the captain
-2	Voice identified as the first officer
-MECH	Voice identified as a mechanic
-WB	Voice identified as weight and balance personnel
-?	Voice unidentified

[1] Due to damage, the serial number of the recorder could not be determined.

*	Unintelligible word
#	Expletive
( )	Questionable insertion
]	Editorial insertion

Note 1: Times are expressed in central daylight time (CDT).

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.

CVR Quality Rating Scale

The levels of recording quality are characterized by the following traits of the cockpit voice recorder information:

Excellent Quality Virtually all of the crew conversations could be accurately and easily understood. The transcript that was developed may indicate only one or two words that were not intelligible. Any loss in the transcript is usually attributed to simultaneous cockpit/radio transmissions that obscure each other.

Good Quality Most of the crew conversations could be accurately and easily understood. The transcript that was developed may indicate several words or phrases that were not intelligible. Any loss in the transcript can be attributed to minor technical deficiencies or momentary dropouts in the recording system or to a large number of simultaneous cockpit/radio transmissions that obscure each other.

Fair Quality The majority of the crew conversations were intelligible. The transcript that was developed may indicate passages where conversations were unintelligible or fragmented. This type of recording is usually caused by cockpit noise that obscures portions of the voice signals or by a minor electrical or mechanical failure of the CVR system that distorts or obscures the audio information.

Poor Quality Extraordinary means had to be used to make some of the crew conversations intelligible. The transcript that was developed may indicate fragmented phrases and conversations and may indicate extensive passages where conversations were missing or unintelligible. This type of recording is usually caused by a combination of a high cockpit noise level with a low voice signal (poor signal-to-noise ratio) or by a mechanical or electrical failure of the CVR system that severely distorts or obscures the audio information.

Unusable Crew conversations may be discerned, but neither ordinary nor extraordinary means made it possible to develop a meaningful transcript of the conversations. This type of recording is usually caused by an almost total mechanical or electrical failure of the CVR system.

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
START OF RECORDING[1]			
03:14:07.3 CDT **START OF TRANSCRIPT**			
03:13:39.5 **CAM**	[power applied to CVR]		
03:14:07.3 **CAM**	[unintelligible voice likely of first officer (f/o) of accident flight talking to an unidentified other person. f/o seems to be talking about range vs. payload mode.]		
03:15:08.8 **CAM**	[multiple sounds of tone, similar to ACARS message alerts, received prior to engine start] [also, multiple sounds of various unidentified voices and clicks and clunks and warnings]		
03:26:42.7 **WXRADAR**	monitor radar display. go around. windshear ahead. windshear ahead. windshear ahead. [crew initiated weather radar test]		
03:28:21.7 **EGPWS**	glideslope. pull up. terrain ahead pull up. [crew initiated EGPWS test]		
03:28:39.6 **CAM**	[accident crew talking about fuel transfer, mostly unintelligible]		
03:31:40.8 **TCAS**	TCAS Test. TCAS Test Pass. [crew initiated TCAS test]		
03:32:21.3 **CAM**	[first officer tests a panel, notes progress to captain]		

[1] The CVR recording began 30 minutes and 20 seconds before the start of the transcript.

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
03:34:11.1 **CAM**	[crew discussion and entry of preliminary weight and balance information, partly unintelligible]		
03:36:10.9 **CAM-1**	before start to the line.		
03:36:12.8 **CAM-2**	okay.		
03:36:13.9 **CAM-2**	oxygen.		
03:36:14.7 **CAM-1**	checked one hundred percent.		
03:36:15.3 **CAM-2**	checked one hundred percent.		
03:36:16.3 **CAM-2**	flight *.		
03:36:17.4 **CAM-1**	alright right side. fifteen twenty two and three zero zero eight.		
03:36:23.3 **CAM-2**	fifteen twenty two and three zero zero eight set.		
03:36:26.6 **CAM-2**	fuel quantity.		
03:36:27.3 **CAM-1**	(** six) takeoff fuel (* four).		
03:36:30.6 **CAM-2**	overhead panel.		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
03:36:32.2 **CAM-1**	set.		
03:36:32.7 **CAM-2**	brakes.		
03:36:33.6 **CAM-1**	checked norm on.		
03:36:34.2 **CAM-2**	parking brake.		
03:36:34.8 **CAM-1**	set.		
03:36:35.9 **CAM-2**	(down to the line complete).		
03:36:37.2 **CAM-1**	alright.		
03:36:38.5 **CAM-1**	[captain begins takeoff brief] (okay it's my turn again). (left seat three hundred and three thousand pound take off. flaps fifteen zero). profile.		
03:36:46.1 **CAM-1**	five thousand three five right. pink page. basically ah...		
03:36:53.5 **CAM-1**	** weight * (thirty) five right. ** climbing right hand turn.		
03:36:59.8 **CAM-1**	DME off the localizer. to a magnetic heading of zero zero five. basically stay clear of ah Humana. [chuckle].		
03:37:07.7 **CAM-2**	(okay).		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
03:37:08.5 **CAM-1**	and uhhh. **. gonna be runway heading. five thousand. turn on course.		
03:37:15.5 **CAM-1**	as far as the reject. eighty knots. call it out loud and clear. ahhh. after v-one ahh. high speed. critical items only. after v-one ** pink page. transition altitude eighteen thousand ft.		
03:37:31.0 **CAM-1**	this is ramp six so ahh push outt'a here right turn. runway (three five right) is close. so uhm probably won't be a problem on the engines. (* call it complete).		
03:37:41.9 **CAM-2**	(sounds good).		
03:37:44.1 **CAM-1**	numbers.		
03:37:45.7 **CAM-2**	* we're gonna be [unintelligible].		
03:38:14.4 **CAM**	[crew discussion, mostly unintelligible]		
03:40:55.2 **CAM**	[sound similar to ACARS alert, captain notes weight and balance]		
03:40:58.8 **INT-MECH**	good morning captain maintenance standing by.		
03:41:22.5 **CAM**	[first officer and captain discuss weight and balance and acknowledging ACARS message.]		
03:41:53.0 **CAM-1**	we have two extra hours today in Birmingham.		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
03:41:58.0 **CAM-1**	Rockford is only fourteen hours and * minutes rest. so you figure a thirty minute ride to-for hotel....		
03:42:04.1 **CAM-2**	I know by the time you...		
03:42:06.0 **CAM-1**	...fourteen hours...		
03:42:08.1 **CAM-1**	...by the time you go to sleep you are down to about twelve. (wow).		
03:42:14.5 **CAM-1**	this is where ah the passenger side you know the new rules they're gonna make out.		
03:42:17.0 **CAM-2**	they're gonna make out.		
03:42:18.3 **CAM-1**	yeah. we need that too.		
03:42:20.2 **CAM-1**	I mean I [stammer[2]] don't get that. you know it should be one level of safety for everybody.		
03:42:23.1 **CAM-2**	it makes no sense at all.		
03:42:24.3 **CAM-1**	no it doesn't at all.		

[2] Stammer is used to describe an utterance with many quick hesitations.

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
03:42:25.5 **CAM-2**	I know. I know.		
03:42:26.2 **CAM-1**	nope.		
03:42:27.9 **CAM-1**	which means that you know * real pilot.		
03:42:30.4 **CAM-1**	you know.		
03:42:32.1 **CAM-2**	and to be honest. [stammer] it should be across the board. to be honest in my opinion whether you are flying passengers or cargo or you know box of chocolates at night. if you're flying this time of day...		
03:42:36.9 **CAM-1**	mm hmm.		
03:42:44.9 **CAM-1**	yup.		
03:42:48.2 **CAM-1**	(we work).		
03:42:49.1 **CAM-2**	...the you know [stammer] * fatigue is definitely...***.		
03:42:49.7 **CAM-1**	yeah...yeah...yeah...**.		
03:42:54.0 **CAM-2**	I was out and I slept today. I slept in Rockford. I slept good.		
03:42:59.3 **CAM-1**	me too.		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
03:43:00.1 **CAM-2**	and I was out in that sleep room and when my alarm went off I mean I'm thinkin' I'm so tired...		
03:43:06.1 **CAM-1**	I know.		
03:43:06.1 **CAM-2**	...and I slept today.		
03:43:07.6 **CAM-1**	exactly.		
03:43:08.1 **CAM-2**	I you know and we just are goin' to Birmingham. what if I was goin' to Burbank?		
03:43:10.6 **CAM-1**	and these people---		
03:43:11.8 **CAM-1**	really God I know these people have no clue. I know.		
03:43:14.8 **CAM-2**	and I just don't understand what they---		
03:43:17.5 **CAM-1**	and they you know they talk about cost. well on the passenger side it just costs just as much. the same thing. you know I mean give me a break. (and these companies are the ones that are really making the money). they got a lot nerve.		
03:43:22.0 **CAM-2**	exactly.		
03:43:23.6 **CAM-2**	exactly.		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
03:43:28.2 **CAM-2**	making the money.		
03:43:29.9 **CAM-2**	I know (I).		
03:43:30.9 **CAM-1**	yeah they do that [stammering] * says [stammering] a lot about what they how they think about you.		
03:43:34.3 **CAM-2**	* says a lot *.		
03:43:38.6 **CAM-WB**	**. [weight and balance personnel]		
03:43:41.0 **CAM-WB**	you'all ready to go?		
03:43:42.6 **CAM-1**	yessir.		
03:43:46.9 **CAM-WB**	there you go.		
03:44:05.6 **CAM**	[individual words mostly unintelligible. crew discussing final weight and balance].		
03:45:38.8 **CAM**	[sound of clicks and snaps, indistinct voice saying thank you]		
		03:46:31.3 **RDO-2**	thirteen fifty four is load complete.
		03:46:36.8 **UPSRAMP**	thirteen fifty four you are cleared for immediate. you have a nice flight.

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
		03:46:40.3 **RDO-2**	cleared for immediate have a good one.
03:46:47.2 **CAM**	[sound of clicks, clunks, similar to main entry door closing and captain sitting down in cockpit]		
03:47:08.1 **CAM**	**.		
03:47:50.7 **CAM-1**	** I think we are the lone ones on this ramp.		
03:47:56.7 **CAM-2**	** I think you're right.		
03:47:58.5 **CAM-1**	yep. yeah.		
		03:48:02.3 **INT**	[captain and mechanic discuss engine start]
03:48:11.4 **CAM-1**	below the line.		
03:48:19.8 **HOT-2**	logbook.		
03:48:20.5 **HOT-1**	on board and signed.		
03:48:21.4 **HOT-2**	seat belt sign.		
03:48:22.5 **HOT-1**	it's on.		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
03:48:24.0 **HOT-2**	I'm supposed to say onboard and signed too.		
03:48:25.9 **HOT-2**	v-speeds.		
03:48:26.3 **HOT-1**	one fifty three. one fifty seven. one sixty set.		
03:48:28.2 **HOT-2**	fifty three. fifty seven. sixty set.		
03:48:29.9 **HOT-2**	CDU.		
03:48:30.6 **HOT-1**	set.		
03:48:30.9 **HOT-2**	set. doors and windows.		
03:48:31.9 **HOT-1**	closed slide armed.		
03:48:32.5 **HOT-2**	closed slide armed. before start complete.		
03:48:34.2 **HOT-1**	thank you.		
03:48:35.1 **INT-1**	okay sir we are ready to start when you guys get all set down there.		
		03:48:39.3 **INT-MECH**	copy.
03:50:14.6 **HOT-1**	okay come on let's go.		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
03:50:16.8 **HOT-2**	I know. * what's goin' on now.		
		03:50:53.9 **INT-MECH**	alright captain. marshalling is finally clear. you are cleared for start your discretion.
03:50:58.3 **INT-1**	okay turning two.		
03:50:59.6 **HOT-1**	turn two.		
03:51:04.4 **HOT-2**	two's turning.		
03:51:16.1 **CAM**	[sound of engine, similar to engine start]		
03:52:16.9 **INT-1**	turning one.		
		03:52:19.0 **INT-MECH**	copy cleared for start.
03:52:21.0 **HOT-1**	turn one.		
03:52:24.2 **CAM**	[sound of engine, similar to engine start]		
03:53:49.7 **HOT-1**	after start.		
03:53:50.7 **HOT-2**	after start.		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
03:53:51.7 **CAM**	[sound of clicks and clunks, similar to after start first officer flow]		
03:54:04.4 **HOT-2**	after start. anti-ice.		
03:54:05.7 **HOT-1**	off.		
03:54:06.3 **HOT-2**	ignition.		
03:54:06.7 **HOT-1**	off.		
03:54:07.1 **HOT-2**	auto-brakes.		
03:54:07.7 **HOT-1**	max.		
03:54:08.1 **HOT-2**	speed brakes.		
03:54:08.7 **HOT-1**	armed.		
03:54:09.2 **HOT-2**	trim.		
03:54:09.7 **HOT-1**	zero. zero. point four nose down set.		
03:54:12.8 **HOT-2**	checked. after start checklist complete.		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
03:54:14.8 **INT-1**	okay so we have two good starts and you're cleared to disconnect. appreciate your help. and we'll see you next time.		
		03:54:20.6 **INT-MECH**	copy. you got two good starts. bypass pin never installed. doors are secured. have a safe and pleasant trip. see you next time through.
03:54:42.3 **HOT-2**	clear over here as far as I can see.		
03:54:44.4 **HOT-1**	okay.		
03:54:50.0 **HOT-2**	here. here he comes. **.		
03:54:52.6 **HOT-1**	okay.		
03:54:56.5 **HOT-2**	I don't see nobody now.		
03:54:58.3 **HOT-1**	okay clear left.		
03:55:01.5 **HOT-1**	slats extend.		
03:55:02.8 **HOT-2**	slats extend.		
03:55:03.8 **CAM**	[sound of clicks, similar to flap handle]		
		03:55:58.8 **RDO-2**	hello ground UPS thirteen fifty four heavy alpha spot six ready to taxi.

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
03:56:04.4 **HOT-2**	of course. of course. of course.		
		03:56:07.1 **GND**	two people calling at once. the woman calling ground say again.
		03:56:11.0 **RDO-2**	UPS thirteen fifty four heavy information alpha spot six taxi.
		03:56:19.5 **GND**	UPS thirteen fifty four heavy Louisville Ground. follow heavy MD-eleven ahead and to your left for runway three five right. taxi via Delta.
		03:56:29.4 **RDO-2**	we'll follow the MD out to three five right via Delta for UPS thirteen fifty four heavy.
03:56:33.5 **HOT-1**	alright follow the airplane to the left.		
03:56:37.2 **HOT-1**	clear on the tops when you get a chance.		
03:56:38.8 **HOT-2**	all righty.		
03:57:00.2 **HOT-2**	tops are good.		
03:57:01.1 **HOT-1**	okay right rudder.		
03:57:03.1 **HOT-2**	right box.		
03:57:04.1 **HOT-1**	and left rudder.		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
03:57:06.4 **HOT-2**	left box rudder checks.		
03:58:13.8 **HOT-1**	okay left seat. three hundred and two thousand pound take-off. flaps fifteen zero profile up to five thousand. off the right side. pink page [stammering] is going to be reviewed and its complete. unless there's any questions?		
03:58:26.8 **HOT-2**	sounds good.		
03:58:27.8 **HOT-1**	before takeoff check.		
03:58:28.5 **HOT-2**	before takeoff checklist flaps.		
03:58:30.8 **HOT-1**	fifteen zero.		
03:58:32.0 **HOT-2**	fifteen zero. flight controls.		
03:58:33.8 **HOT-1**	checked.		
03:58:34.3 **HOT-2**	checked. TRP V speeds.		
03:58:35.8 **HOT-1**	set.		
03:58:36.6 **HOT-2**	set. ignitions. continuous relight. bleeds and packs are set. one's off just for noise. takeoff configuration is normal for takeoff. before takeoff checklist complete.		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
03:58:46.1 **HOT-1**	thank you.		
		04:00:03.9 **TWRSDF**	Louisville International information Bravo current.
		04:00:39.2 **TWRSDF**	UPS thirteen fifty four heavy Louisville Tower runway three five right line up and wait.
		04:00:43.0 **RDO-2**	line up and wait three five right. thirteen fifty four heavy.
04:00:46.0 **HOT-1**	alright line up and wait three five right. right side verified.		
04:00:47.8 **HOT-2**	line up and wait.		
04:00:51.1 **HOT-2**	final's cleared. three zero zero nine's the new altimeter.		
04:00:54.1 **HOT-1**	thirty oh nine.		
04:01:50.8 **HOT-2**	three five right's verified.		
04:01:53.0 **HOT-1**	yeah.		
		04:02:17.9 **TWRSDF**	UPS thirteen fifty four heavy fly runway heading runway three five right cleared for takeoff.
		04:02:22.0 **RDO-2**	fly runway heading runway three five right cleared for takeoff UPS thirteen fifty four heavy.

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
04:02:26.1 **HOT-1**	cleared to go.		
04:02:26.7 **HOT-2**	cleared to go runway heading.		
04:02:28.6 **CAM**	[sound of increased noise, similar to engine spool up]		
04:02:33.6 **HOT-1**	set takeoff thrust.		
04:02:45.6 **HOT-2**	thrust set.		
04:02:49.1 **HOT-2**	eighty knots.		
04:02:49.8 **HOT-1**	checked.		
04:03:05.3 **HOT-2**	v-one rotate. v-two.		
04:03:13.2 **HOT-2**	positive rate.		
04:03:14.0 **HOT-1**	gear up.		
04:03:21.8 **HOT-1**	heading select.		
04:03:22.7 **HOT-2**	heading select.		
		04:03:46.9 **TWRSDF**	UPS thirteen fifty four heavy contact departure have a good flight.

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
		04:03:50.1 **RDO-2**	departure have a good one.
		04:03:53.2 **RDO-2**	(hello) departure UPS thirteen fifty four heavy two point six climbing to five thousand runway heading.
		04:03:57.7 **APRSDF**	UPS thirteen fifty four heavy Louisville Departure good morning you're radar contact. climb and maintain one zero thousand.
		04:04:03.1 **RDO-2**	one zero thousand UPS thirteen fifty four heavy.
04:04:05.5 **HOT-1**	ten thousand.		
04:04:07.0 **HOT-1**	slats retract.		
04:04:07.0 **HOT-2**	ten thousand.		
04:04:07.8 **HOT-2**	slats retract.		
04:04:08.5 **HOT-1**	after takeoff checklist.		
04:04:09.5 **HOT-2**	after takeoff checklist.		
04:04:22.1 **HOT-2**	after takeoff checklist complete.		
04:04:23.9 **HOT-1**	thank you.		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
		04:04:24.5 **APRSDF**	UPS thirteen fifty four heavy turn right heading zero niner zero.
		04:04:27.4 **RDO-2**	right turn zero niner zero UPS thirteen fifty four heavy.
04:04:31.0 **HOT-1**	zero nine zero.		
04:04:33.4 **HOT-2**	zero nine zero.		
		04:05:21.6 **APRSDF**	UPS thirteen fifty four heavy turn right direct Bowling Green.
		04:05:25.2 **RDO-2**	right turn direct Bowling Green UPS thirteen fifty four heavy.
04:05:27.7 **HOT-1**	right turn going to Bowling Green.		
04:05:35.8 **HOT-1**	look's good. I'll take it.		
04:05:43.6 **HOT-2**	nav's available.		
04:05:45.2 **HOT-1**	nav.		
04:05:45.7 **HOT-2**	nav is selected.		
04:05:46.8 **HOT-1**	thank you.		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
		04:06:10.2 **APRSDF**	UPS thirteen fifty four heavy contact Indy Center one two one point one seven. twenty one seventeen. we'll see ya.
		04:06:15.8 **RDO-2**	twenty one seventeen. have a good day. thirteen fifty four.
04:06:26.8 **HOT-1**	nine for ten.		
04:06:27.7 **HOT-2**	one to go.		
		04:06:28.5 **RDO-2**	(Indy) Center UPS thirteen fifty four nine point three for one zero thousand direct Bowling Green.
		04:06:34.5 **CTRINDY**	UPS thirteen fifty four Indy Center roger cleared direct Birmingham climb maintain flight level two three zero.
		04:06:39.8 **RDO-2**	direct Birmingham and up to two three zero for thirteen fifty four.
04:06:43.9 **HOT-1**	twenty three is in the box. out of ten. direct Birmingham.		
04:06:44.3 **HOT-2**	twenty three and direct Birmingham.		
04:07:02.7 **HOT-2**	nav is available and selected.		
04:07:04.5 **HOT-1**	roger. roger nav's armed.		
04:07:13.5 **HOT-2**	ops normal away.		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
04:07:32.6 **HOT-2**	winds are calm still in Birmingham. ten miles. broken at a thousand.		
04:07:43.0 **HOT-1**	autopilot one command.		
04:07:44.7 **HOT-2**	autopilot one command.		
		04:10:02.5 **CTRINDY**	UPS thirteen fifty four climb and maintain flight level two eight zero.
		04:10:07.0 **RDO-2**	two eight zero thirteen fifty four.
04:10:09.4 **HOT-1**	two eight oh.		
04:10:10.1 **HOT-2**	twenty eight.		
04:10:18.4 **HOT-1**	alright ninety two set.		
04:10:19.7 **HOT-2**	ninety two set.		
		04:13:34.3 **CTRINDY**	UPS thirteen fifty four contact Memphis Center one two four point one two.
		04:13:39.4 **RDO-2**	twenty four twelve UPS thirteen fifty four goodnight.
		04:13:47.6 **RDO-2**	good morning Memphis UPS thirteen fifty four twenty four eight climbing two eight zero.

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
		04:13:52.9 **CTRMEM1**	UPS thirteen fifty four Memphis Center roger.
04:14:48.3 **HOT-2**	one to go.		
04:14:49.6 **HOT-1**	one to go.		
04:16:03.2 **HOT-1**	**.		
04:16:06.0 **HOT-2**	I like it.		
04:16:11.6 **HOT-1**	**.		
04:16:12.3 **HOT-2**	that's the way every flight should be.		
04:16:23.2 **HOT-1**	(you can't bid to hold *.)		
04:16:24.8 **HOT-2**	I know. I know.		
04:16:26.2 **HOT-1**	* you might get something *.		
04:16:28.1 **HOT-1**	this bid period and the next one you get something completely different. yep.		
04:16:30.3 **HOT-2**	* it's crazy.		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
		04:20:53.4 **ATIS**	Birmingham Airport information Papa zero eight five three Zulu observation wind calm visibility one zero. sky condition ceiling one thousand broken. seven thousand five hundred overcast. temperature two three. dewpoint two two. altimeter two niner niner seven. localizer runway one eight in use. landing and departing runway one eight. notice to airmen runway six two-four closed. all departing aircraft contact tower one one niner point niner for clearance taxi and takeoff. advise controller on initial contact you have Papa.
04:21:23.9 **HOT-2**	well. did you hear any of Papa?		
04:21:27.1 **HOT-1**	I didn't hear any of it.		
04:21:28.1 **HOT-2**	they're sayin' six and two-four is closed. they're doin' the localizer to one eight.		
04:21:33.0 **HOT-1**	localizer (to) one eight. it figures.		
04:21:35.3 **HOT-2**	I know. especially since were [stammer] a little heavy. I mean [chuckle].		
04:21:40.8 **HOT-1**	yep.		
04:23:15.5 **HOT-1**	alright. I guess I'll brief it. briefing guide.		
04:23:17.9 **HOT-2**	(okay).		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
04:23:22.1 **HOT-1**	so review profile approach summary table for approach set-up. aaaaannnndddd.		
04:23:31.7 **HOT-1**	GPS primary doesn't apply to localizer. RNP doesn't apply.		
04:23:36.9 **HOT-1**	FMC disagree doesn't apply. temperature not applicable.		
04:23:45.7 **HOT-1**	ahhh. verify VNAV path on approach chart. ah it is.		
04:23:56.6 **HOT-1**	ILS glideslope out approaches.		
04:24:00.5 **HOT-1**	VNAV path is the same as the ILS glideslope.		
04:24:11.2 **HOT-1**	alright and uh. determine DA or D-DA and set altimeter bugs. and there is a note there only-only authorized operators may use VNAV DA in lieu of uhm MDA. alright so it will be twelve hundred for us. and uhhh.		
04:24:19.4 **HOT-2**	mmm hmm.		
04:24:25.9 **HOT-2**	twelve hundred huh.		
04:24:34.3 **HOT-1**	okay. and in case uh a barometric DA may be utilized on the following approaches. ILS glideslope out. or approaches titled ILS or localizer runway. which is this case. or ILS or localizer DME runway bla bla bla.		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
04:24:52.8 **HOT-1**	all approaches with VNAV ball note. ball note states only authorized operators may use VNAV DA in lieu of MDA.		
04:25:00.8 **HOT-1**	alright. this is US airspace. load approach in FMC database. enter DA. or D-DA on approach page.		
04:25:17.2 **HOT-1**	okay and uh. verify database vertical path angle agrees with approach chart within one degree.		
04:25:29.9 **HOT-2**	[mumbling] ** verify * approach to * point one degrees.		
04:25:30.8 **HOT-1**	okay.		
04:25:35.3 **HOT-1**	and.		
04:25:37.8 **HOT-1**	adjust approach on approach page if necessary. v-approach. that's not necessary.		
04:25:42.5 **HOT-1**	accomplish the brief. briefing and activate final approach mode.		
04:25:47.0 **HOT-1**	and in the last note. select profile and verify P descent on an ILS glideslope out approaches or localizer approaches when the VNAV path crosses the final approach fix below the FAF minimum altitude. start a one thousand ft per minute descent at the FAF and immediately select profile mode to capture the path.		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
04:26:06.5 **HOT-1**	so. ahhh eleven dash two is the plate. seventeen august twelve. localizer frequency is one eleven three. final approach course is one eight three. and ah.		
04:26:27.4 **HOT-1**	BASKN is the ahhh final approach fix. twenty three hundred ft. down to a ah DA of twelve hundred. five sixty ah on the radio altimeter.		
04:26:41.2 **HOT-1**	touchdown zone is six forty four and airport's six fifty. MSA is thirty seven hundred ft and it's based on the Vulcan VOR.		
04:26:49.4 **HOT-1**	missed approach climb to fifteen hundred ft on a heading one eight three. and a climbing left turn to thirty eight hundred ft on the Vulcan one thirty seven radial. and outbound to handle [missed approach fix is HANDE]. twenty seven point--twenty eight point six off of Vulcan and hold or as directed by ATC.		
04:27:08.9 **HOT-1**	so if that's the case this morning then we'll just follow the nav path for the missed.		
04:27:13.4 **HOT-1**	missed approach will be go-around thrust flaps positive rate gear up. four hundred ft nav. thousand ft autopilot one command. fifteen hundred ft climb thrust and at alt star we'll set green dot and clean it up on schedule.		
04:27:23.3 **HOT-1**	for the discontinued approach outside of anap [stammer] a thousand I'll announce discontinued approach. altitude hold probably one sixty...		
04:27:29.8 **HOT-1**	once we're ahhh accelerating and stable it'll be ahhh flaps and gear. the runway we just talked about...		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
04:27:33.6 **HOT-2**	okay.		
04:27:37.7 **HOT-1**	...it's short.		
		04:27:38.5 **CTRMEM1**	UPS thirteen fifty four contact Atlanta Center one two eight point seven two.
		04:27:45.6 **RDO-2**	twenty eight seventy two UPS thirteen fifty four.
		04:27:53.2 **RDO-2**	Atlanta UPS thirteen fifty four two eight zero.
		04:27:56.5 **CTRATL1**	UPS thirteen fifty four Atlanta Center roger.
04:27:59.9 **HOT-1**	alright it's got REIL PAPI on the left...		
04:28:01.9 **HOT-1**	it's a three point two degree angle....and uh...		
		04:28:03.2 **CTRATL1**	attention all aircraft hazardous weather inf-- AIRMET for Tennessee, Kentucky, West Virginia, Louisiana, Mississippi, and Alabama available on HIWAS Flight Watch Flight Service frequencies.
04:28:11.3 **HOT-1**	probably use most of this today. probably either probably Golf at the end. and uh.		
04:28:20.7 **HOT-1**	I think on this one they bring you off on ah Bravo--		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
		04:28:22.4 **CTRATL1**	Delta thirteen fifty four Atlanta approach one two five point seven.
04:28:23.4 **HOT-2**	(okay)		
		04:28:27.4 **AC**	uh that was twenty five point seven Delta thirteen fifty four.
		04:28:30.7 **RDO-?**	altimeter two niner niner seven.
04:28:30.8 **HOT-1**	Delta thirteen fifty four. wow.		
04:28:33.7 **HOT-2**	what was that?		
04:28:34.4 **HOT-1**	Delta thirteen fifty four. it's the same as our number.		
04:28:36.3 **HOT-2**	I know it's the same as ours *.		
04:28:37.5 **HOT-1**	yeah.		
04:28:39.9 **HOT-1**	okay so it'll be Bravo to ah...Foxtrot...which will be a left turn and then down to the UPS ramp. low brakes.		
04:28:55.0 **HOT-1**	and the only other thing we gotta do is when I come out of ahh...I guess I'll do that now--		
		04:28:58.4 **CTRATL1**	UPS thirteen fifty four descend at pilot's discretion maintain flight level two four zero.

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
		04:29:03.2 **RDO-2**	pilot's discretion two four zero UPS thirteen fifty four.
04:29:06.2 **HOT-1**	oh pilot's discretion two four zero. okay.		
04:29:09.6 **HOT-1**	so that's good three point three...and...ahhh...twelve hundred...and we'll just activate final when we start down.		
04:29:16.4 **HOT-2**	we'll just activate that once we're on the uh. you notice this radio hasn't shut up since we took-- I mean it's been chatter the whole time [chuckle].		
04:29:17.6 **HOT-1**	(yeah). (yeah). oh I know. I know. on this particular trip. yeah.		
04:32:08.2 **HOT-1**	two four zero.		
		04:32:12.7 **RDO-2**	and UPS thirteen fifty four leaving two eight zero for two four zero.
		04:32:18.7 **CTRATL1**	FedEx thirteen fifty four roger.
04:32:21.0 **HOT-1**	UPS.		
		04:32:21.1 **RDO-2**	no it's UPS thirteen fifty four.
		04:32:22.9 **CTRATL1**	sorry UPS thirteen fifty four roger.
04:32:25.9 **HOT-1**	the other airline [chuckle].		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
04:32:26.9 **HOT-2**	I know. it's the other one. the F word er. not the F word * [trails off to chuckle].		
04:32:35.7 **HOT-2**	I just want'a make sure---you remember that in recurrent? you remember there was like ah...		
04:32:38.7 **HOT-1**	[chuckle].		
04:32:40.3 **HOT-2**	...some other aircraft following another...when there's...cause I thought you said there was a Delta thirteen fifty four. so I wanted to make sure (they) [trails off to chuckle].		
04:32:46.8 **HOT-1**	mmm hmmm.		
04:32:49.4 **HOT-2**	so he knew who was doin' what [chuckle].		
04:32:51.1 **HOT-1**	yeah...exactly [chuckle].		
04:32:53.4 **HOT-1**	like who we are.		
04:32:54.6 **HOT-2**	mmm hmmm.		
		04:33:09.8 **CTRATL1**	UPS thirteen fifty four contact Memphis Center one two zero point eight.
		04:33:14.3 **RDO-2**	one two zero point eight UPS thirteen fifty four. good night.

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
		04:33:20.6 **RDO-2**	morning Memphis UPS thirteen fifty four twenty five seven for two four zero.
		04:33:26.0 **CTRMEM2**	UPS thirteen fifty four Memphis Center roger descend at pilot's discretion maintain one one thousand. Birmingham altimeter two niner niner six.
		04:33:32.7 **RDO-2**	pilot's discretion one one thousand. Birmingham twenty nine-ninety six for thirteen fifty four.
04:33:37.5 **HOT-1**	alright discretion level we'll keep it goin'.		
04:33:39.9 **HOT-2**	keep 'er goin'.		
		04:33:42.2 **RDO-2**	and for UPS thirteen fifty four we're just keep 'er goin' down to eleven.
		04:33:45.8 **CTRMEM2**	roger.
04:34:09.9 **HOT-1**	they're generous today. usually they kind'a take you to fifteen and they hold you up high.		
04:34:11.0 **HOT-2**	I know. hold you up there.		
		04:37:03.7 **CTRMEM2**	UPS thirteen fifty four contact Atlanta Center one two seven point three.

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
		04:37:08.1 **RDO-2**	one twenty seven point three UPS thirteen fifty four.
		04:37:15.8 **RDO-2**	er Atlanta UPS thirteen fifty four out of one eight oh for one one thousand.
04:37:18.1 **CAM**	[sound of four clacks/clunks]		
		04:37:21.3 **CTRATL2**	UPS thirteen fifty four latest weather Birmingham altimeter two niner niner six.
		04:37:25.1 **RDO-2**	ninety six thirteen fifty four.
04:37:27.3 **HOT-1**	ninety six. approach checklist.		
04:37:29.4 **HOT-2**	ninety six. approach checklist.		
04:37:34.1 **HOT-2**	seat belt sign is on. landing elevation is set to six fifty. autobrakes are set to low. ECAM status is checked. standby airspeed bugs...		
04:37:42.9 **HOT-1**	one thirty seven. two ahhh seventeen set.		
04:37:45.4 **HOT-2**	...thirty seven. two seventeen set. altimeters.		
04:37:48.5 **HOT-1**	two nine nine six set twice.		
04:37:50.2 **HOT-2**	twenty nine ninety six set. approach checklist complete.		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
04:37:53.2 **HOT-1**	alright thank you.		
04:40:24.3 **HOT-1**	one to go.		
04:40:25.3 **HOT-2**	one to go.		
04:40:49.5 **CAM**	[background sound decreases, similar to reduction in airspeed. lower sound continues until gear extension]		
04:41:26.1 **HOT-2**	(let) me ask him for lower or?		
04:41:28.6 **HOT-1**	mmm hmm.		
		04:41:30.6 **RDO-2**	is there any chance for lower for UPS thirteen fifty four?
		04:41:33.1 **CTRATL2**	UPS thirteen fifty four contact Birmingham Approach one two seven point six seven. goodday.
		04:41:37.3 **RDO-2**	twenty seven sixty seven goodday.
		04:41:43.6 **RDO-2**	Birmingham UPS thirteen fifty four we're at one one thousand we have papa look'n for lower.
		04:41:49.4 **TWRBHM1**	UPS thirteen fifty four heavy Birmingham Tower descend and maintain three thousand and uhm...runway six is still closed. you want to ah want the localizer one eight?

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
04:41:59.5 **HOT-1**	yep.		
		04:42:00.2 **RDO-2**	yessir the localizer one eight will work.
		04:42:02.0 **TWRBHM1**	[static] copy that.
		04:42:04.8 **TWRBHM1**	UPS thirteen fifty four heavy turn ten degrees right join the localizer maintain three thousand.
		04:42:09.2 **RDO-2**	okay. ten right join the localizer. maintain three thousand. thirteen fifty four heavy.
04:42:13.1 **HOT-1**	ten right join the localizer.		
04:42:14.9 **CAM**	[sound of click]		
04:42:16.1 **HOT-2**	I don't think we have many choices if runway six is [laughter].		
04:42:17.7 **HOT-1**	ahhh [laughter] I know what else can we do [laughing]?		
04:42:19.0 **HOT-2**	and when he said there for me I'm like ahhh well what else ahh you gonna unroll another one out there for us real quick or whatever [chuckling].		
04:42:20.9 **HOT-1**	it's like...okay....yeah you got another ... yeah you got an ILS on some'n else? [chuckling]		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
04:42:25.2 **HOT-2**	uhh...I know [chuckling].		
04:42:38.1 **HOT-1**	gear down.		
04:42:40.3 **HOT-2**	gear down speed checks.		
04:42:40.7 **CAM**	[sound of multiple clicks, similar to landing gear handle movement]		
04:42:42.1 **CAM**	[sound of snap and increased noise, similar to landing gear extension]		
04:42:52.1 **HOT-1**	and they keep you high [laughter].		
04:42:53.8 **HOT-2**	at at'll getch'ya down [chuckling]...		
04:42:55.2 **HOT-1**	oh I know. I * [chuckling].		
04:42:55.7 **HOT-2**	...yeah they were doin' good until...then...		
04:42:57.0 **HOT-1**	eh I know it's unbelievable [chuckling].		
04:42:58.5 **HOT-2**	...I kept seein' COLIG come closer and closer. and I'm like oh brother.		
04:43:00.2 **HOT-1**	I know it's like...it's like comin' comin' fast. ah yup [chuckling].		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
04:43:09.4 **HOT-1**	divin' for the airport. unbelievable.		
		04:43:24.3 **TWRBHM1**	UPS thirteen fifty four heavy is one one miles from BASKIN maintain two thousand five hundred till established on localizer. cleared localizer one eight approach.
		04:43:32.0 **RDO-2**	two thousand five hundred till established. cleared for the localizer one eight approach UPS thirteen fifty four heavy.
04:43:37.4 **HOT-1**	two point five till established cleared for the localizer.		
04:43:40.4 **HOT-2**	least there's like eight miles between...		
04:43:42.0 **HOT-1**	oh I know this is---		
04:43:43.3 **HOT-2**	...COLIG and BASKIN [chuckle].		
04:43:53.5 **HOT-2**	there's loc star.		
04:43:53.6 **HOT-1**	loc's alive.		
04:43:55.7 **HOT-1**	one eight three set.		
04:44:05.5 **HOT-2**	[dash dash dash...dot dot dash dot dot dash] [may be two idents at same time, one sounds similar to DME]		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
04:44:11.6 **HOT-1**	you can activate that...		
04:44:12.1 **HOT-2**	good ident on the localizer.		
04:44:13.1 **HOT-1**	...activate that final if you haven't already.		
04:44:15.0 **HOT-2**	alright.		
04:44:18.2 **HOT-1**	thirty five for twenty five.		
04:44:19.6 **HOT-2**	thirty five for twenty five. final's activated.		
04:44:37.5 **HOT-1**	slats extend.		
04:44:39.1 **HOT-2**	speed checks. slats extend.		
04:44:40.3 **CAM**	[sound of click, similar to flap handle movement]		
04:44:49.2 **HOT-1**	unbelievable.		
04:44:51.3 **HOT-2**	I know [chuckling].		
		04:44:60.0 **TWRBHM1**	FedEx fourteen eighty eight Birmingham.
		04:45:07.0 **TWRBHM1**	ah should be closed ah about another fifteen minutes.

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
04:45:08.4 **HOT-1**	flaps fifteen.		
04:45:10.2 **HOT-2**	speed checks. flaps fifteen.		
04:45:13.8 **CAM**	[sound of multiple clicks, similar to flap handle]		
		04:45:18.5 **TWRBHM1**	UPS thirteen fifty four heavy change to my frequency one one niner point niner.
		04:45:22.4 **RDO-2**	nineteen nine.
		04:45:28.9 **RDO-2**	thirteen fifty four up nineteen nine.
		04:45:31.3 **TWRBHM2**	UPS thirteen fifty four heavy runway one eight cleared to land wind calm.
		04:45:34.8 **RDO-2**	one eight cleared to land thirteen fifty four heavy.
04:45:38.3 **HOT-1**	flaps twenty.		
04:45:39.9 **HOT-2**	speed checks flaps twenty.		
04:45:43.3 **CAM**	[sound of multiple clicks, similar to flap handle]		
04:45:50.6 **CAM**	[sound of background noise continues to decrease, similar to airspeed decreasing]		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
04:45:50.9 **HOT-1**	flaps forty speed one thirty seven landing check.		
04:45:53.8 **HOT-2**	okay...		
04:45:54.7 **HOT-1**	set the missed approach altitude.		
04:45:55.0 **HOT-2**	[sound of multiple clicks, similar to flap handle] speed checks flaps forty landing checklist missed approach altitude.		
		04:45:58.5 **TWRBHM2**	airport fifteen tower.
04:46:05.2 **HOT-2**	landing gears down three green pressure check. TRP thrust limit GA.		
04:46:09.1 **HOT-2**	flaps thirty forty.		
		04:46:09.4 **VEH**	tower Airport Twelve * two go ahead.
		04:46:12.7 **TWRBHM2**	Airport Twelve ah are we ah on schedule to open back up at ah one zero Z?
04:46:14.2 **HOT-2**	speed brakes armed. ignition continuous relight.		
04:46:17.4 **HOT-2**	landing checklist complete.		
04:46:18.4 **HOT-1**	unbelievable kept us high...		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
		04:46:19.0 **VEH**	affirm uhm they're very close to the end right now uh.
04:46:24.7 **HOT-2**	let's see you're in...vertical speed...okay.		
		04:46:24.8 **TWRBHM2**	roger.
04:46:27.0 **HOT-1**	...yeah I'm gonna do vertical speed. yeah he kept us high.		
04:46:29.6 **HOT-2**	kept ya high. could never get it over to profile (we didn't) do it like that.		
04:46:31.4 **HOT-1**	uh uh I know.		
04:46:33.7 **HOT-2**	I'll put your missed approach altitude in there.		
04:46:35.7 **HOT-1**	yeah. thank you.		
04:46:46.8 **HOT-1**	alright so at three point three should be at thirteen eighty.		
04:46:49.2 **HOT-2**	damn I'm gonna actually have to...		
04:46:53.7 **HOT-1**	and we're like way high...		
04:46:56.8 **HOT-1**	...or higher [chuckle].		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
04:46:57.1 **HOT-2**	about...a couple hundred ft...yeah.		
04:46:59.4 **HOT-1**	yeah.		
04:47:02.9 **HOT-2**	there's a thousand ft instruments cross checked no flags.		
04:47:05.4 **HOT-1**	alright ah DA is twelve ah hundred.		
04:47:08.1 **HOT-2**	twelve hundred yeah...		
04:47:10.9 **HOT-1**	two miles.		
04:47:19.6 **HOT-2**	it wouldn't happen to be actual [chuckle].		
04:47:21.4 **CAM**	[sound of snap]		
04:47:23.0 **HOT-1**	oh I know.		
04:47:24.5 **EGPWS**	sink rate.		
04:47:25.9 **EGPWS**	sink rate.		
04:47:26.6 **HOT-2**	(there it is) [mumbling].		
04:47:26.7 **HOT-1**	uhhhr.		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
04:47:27.9 **HOT-1**	oh I got the runway out there twelve o'clock.		
04:47:28.5 **HOT-2**	got the runway in sight, eh.		
04:47:29.7 **HOT-1**	autopilot's off.		
04:47:29.9 **HOT-2**	eh.		
04:47:30.6 **HOT-2**	alrighty.		
04:47:31.5 **CAM**	[sound of click, similar to autopilot paddle switch]		
04:47:31.9 **CAM**	[sound of cavalry charge, similar to autopilot disengagement continues for 4.3 seconds]		
04:47:32.5 **CAM**	[sound of rustling, similar to impact, volume increases for about 5.4 seconds]		
04:47:32.9 **HOT-2**	ooh.		
04:47:33.4 **HOT-1**	oh # #.		
04:47:33.5 **EGPWS**	too low terrain [recorded on CAM]		
04:47:35.1 **HOT-1**	oh did I hit (somethin')?		

TIME and SOURCE	INTRA-COCKPIT CONTENT	TIME and SOURCE	COCKPIT-GROUND COMMUNICATION CONTENT
04:47:36.6 **HOT-1**	oh...oh # [exclaiming].		
04:47:37.9 **HOT-2**	oh.		
04:47:37.9 **CAM**	[cessation in rustling/impact sounds]		
04:47:38.3 **HOT-1**	oh. oh God.		
04:47:38.8 **CAM**	[sound of rustling, similar to impact, continues at higher volume until end of recording]		
04:47:39.9 **HOT-?**	[grunting].		
04:47:41.1 **HOT**	[static].		
04:47:41.3 **CAM**	[end of loudest noise]		
04:47:41.6 **HOT**	[end of recording]		

END OF TRANSCRIPT

04:47:41.7 CDT

END OF RECORDING
04:47:41.7 CDT

Appendix C: Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile Comments

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE

Ministère de l'Ecologie,
du Développement durable
et de l'Energie

BEA
Bureau d'Enquêtes et d'Analyses
pour la sécurité de l'aviation civile

Le Bourget, 5 August 2014

National Transportation Safety Board
Dan Bower, IIC

N° **446** /BEA/INV

Subject: Comments to the draft final report concerning the accident that occurred in Birmingham on 14 August 2013 to the Airbus A300 registered N155UP and operated by UPS.

Dear Dan,

Thank you for having associated the BEA with the investigation into the accident to the Airbus A300, registered N155UP, and for the opportunity to make comments on the Draft Final Report. I would also like to reiterate our great appreciation for the spirit of cooperation that has permeated this investigation.

It is in this same spirit, and with the interests of civil aviation safety in mind, that we hereby present you with the appended observations. I hope that they will appear to you to improve the overall comprehension of the accident and that you will accept that they be included into your report. If this is not the case, I would be obliged if you would append the observations from Annex 1 to the report, in accordance with the provisions of Annex 13.

The BEA remains at your disposal for any further information that you may wish to obtain.

Yours sincerely.

Romain Bévillard
Investigation Team Leader
Accredited Representative

Aéroport du Bourget
Zone Sud – Bâtiment 153
200 rue de Paris
93352 Le Bourget Cedex
France
Tél. : +33 1 49 92 72 00
Fax : +33 1 49 92 72 03
www.bea.aero

Annex 1: Comments from BEA

The comment contained in this table has been discussed between Airbus and BEA.

Ref	Page	Commented extract	Reason for proposed change	Proposed amendment
1.	Page 125 Line 14-23 Page 134 Line 15-19 Page 135 Line 6-9	Develop and implement, for applicable Airbus models, means to provide pilots with a direct and conspicuous cue when they program the FMC flight plan incorrectly such that it contains elements such as improper waypoints or discontinuities that would allow the VDI to present misleading information for an approach. **(A-14-XX)**	The NTSB rightly identifies that -Quote - there were several cues1 in the pilots' primary instrument scans that would have alerted them that the FMC was improperly sequenced – Unquote. In addition, the NTSB also considered that the crew -Quote- the crew may have believed that the sequencing was proper because (1) the localizer was captured, (2) the airplane icon was positioned on the localizer on the NAV display, and (3) the first officer was able to activate the approach to runway 18 in the FMC. Hence, the flight crew may have followed cues that supported their expectation of a properly sequenced approach and ignored those that did not support that expectation. – unquote- . Considering the already multiple available cues, it is very unlikely that a crew would consider an additional cue that would help them not to believe elements supporting their expectations. There will always be situation where a crew would disregard information not meeting the crew expectation. As a result, we believe that the option of reinforcing either the operational procedure or reinforcing the associated crew training should also be considered.	Develop and implement, for applicable Airbus models, means (in terms of design and/or SOP and/or training) to enhance crew's capabilities in identifying elements such as improper waypoints or discontinuities that would allow the VDI to present misleading information for an approach. **(A-14-XX)**

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