Rapid Descent and Crash into Water
Atlas Air Inc. Flight 3591
Boeing 767-375BCF, N1217A
Trinity Bay, Texas
February 23, 2019

Accident Report

NTSB/AAR-20/02
PB2020-101004

National
Transportation
Safety Board

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Aircraft Accident Report

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

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Abstract: This report discusses the February 23, 2019, accident involving Atlas Air Inc. flight 3591, a Boeing 767-375BCF, N1217A, that was destroyed after it rapidly descended from an altitude of about 6,000 ft mean sea level and crashed into a shallow, muddy marsh area of Trinity Bay, Texas, about 41 miles east-southeast of George Bush Intercontinental/Houston Airport, Houston, Texas. The captain, first officer, and a nonrevenue pilot riding in the jumpseat died. Safety issues identified in this report include inadvertent activation of the go-around mode, flight crew performance, Atlas' evaluation of the first officer, industry pilot hiring process deficiencies, awareness information for Boeing 767 and 757 pilots, adaptations of automatic ground collision avoidance technology, and cockpit image recorders. As a result of this investigation, the National Transportation Safety Board makes six new safety recommendations and reiterates two safety recommendations to the Federal Aviation Administration.

For more detailed background information on this report, visit the NTSB investigations website and search for NTSB accident ID DCA19MA086. Recent publications are available in their entirety on the NTSB website. Other information about available publications also may be obtained from the website or by contacting—
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Abbreviations

AC	advisory circular
ADI	attitude director indicator
AFDS	autopilot/flight director system
AOA	angle of attack
ASAP	aviation safety action program
ASIAS	Aviation Safety Information and Analysis Sharing
ASRS	aviation safety reporting system
ATC	air traffic control
ATP	airline transport pilot
auto GCAS	automatic ground collision avoidance system
CFR	*Code of Federal Regulations*
CRM	crew resource management
CVR	cockpit voice recorder
DA	designated agent
DoD	US Department of Defense
EFI	electronic flight instrument
EFIS	electronic flight instrument system
EICAS	engine indicating and crew-alerting system
FAA	Federal Aviation Administration
FDM	flight data monitoring
FDR	flight data recorder
FMC	flight management computer
FCOM	flight crew operating manual
FO	first officer

FOM	flight operations manual
FOTM	flight operations training manual
FOQA	Flight Operations Quality Assurance
GIF	gravito-inertial force
HR	human resources
HSI	horizontal situation indicator
IAH	George Bush Intercontinental/Houston Airport
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ILS	instrument landing system
IMC	instrument meteorological conditions
kts	knots
MCP	mode control panel
MIA	Miami International Airport
msl	mean sea level
NASA	National Aeronautics and Space Administration
NDR	National Driver Register
NPRM	notice of proposed rulemaking
PF	pilot flying
PIC	pilot-in-command
PM	pilot monitoring
PRD	pilot records database
PRIA	Pilot Records Improvement Act
PWP	proficiency watch program
SG	symbol generator

SMS	safety management system
TAWS	terrain awareness and warning system
UAS	unmanned aircraft system
VMC	visual meteorological conditions

Executive Summary

On February 23, 2019, at 1239 central standard time, Atlas Air Inc. (Atlas) flight 3591, a Boeing 767-375BCF, N1217A, was destroyed after it rapidly descended from an altitude of about 6,000 ft mean sea level (msl) and crashed into a shallow, muddy marsh area of Trinity Bay, Texas, about 41 miles east-southeast of George Bush Intercontinental/Houston Airport (IAH), Houston, Texas. The captain, first officer (FO), and a nonrevenue pilot riding in the jumpseat died. Atlas operated the airplane as a Title 14 *Code of Federal Regulations* Part 121 domestic cargo flight for Amazon.com Services LLC, and an instrument flight rules flight plan was filed. The flight departed from Miami International Airport (MIA), Miami, Florida, about 1033 (1133 eastern standard time) and was destined for IAH.

The accident flight's departure from MIA, en route cruise, and initial descent toward IAH were uneventful. As the flight descended toward the airport, the flight crew extended the speedbrakes, lowered the slats, and began setting up the flight management computer for the approach. The FO was the pilot flying, the captain was the pilot monitoring, and the autopilot and autothrottle were engaged and remained engaged for the remainder of the flight.

Analysis of the available weather information determined that, about 1238:25, the airplane was beginning to penetrate the leading edge of a cold front, within which associated windshear and instrument meteorological conditions (as the flight continued) were likely. Flight data recorder data indicated that, during the time, aircraft load factors consistent with the airplane encountering light turbulence were recorded and, at 1238:31, the airplane's go-around mode was activated. At the time, the accident flight was about 40 miles from IAH and descending through about 6,300 ft msl toward the target altitude of 3,000 ft msl. This location and phase of flight were inconsistent with any scenario in which a pilot would intentionally select go-around mode, and neither pilot made a go-around callout to indicate intentional activation.

Within seconds of go-around mode activation, manual elevator control inputs overrode the autopilot and eventually forced the airplane into a steep dive from which the crew did not recover. Only 32 seconds elapsed between the go-around mode activation and the airplane's ground impact.

Probable Cause

The NTSB determines that the probable cause of this accident was the inappropriate response by the first officer as the pilot flying to an inadvertent activation of the go-around mode, which led to his spatial disorientation and nose-down control inputs that placed the airplane in a steep descent from which the crew did not recover. Contributing to the accident was the captain's failure to adequately monitor the airplane's flightpath and assume positive control of the airplane to effectively intervene. Also contributing were systemic deficiencies in the aviation industry's selection and performance measurement practices, which failed to address the first officer's aptitude-related deficiencies and maladaptive stress response. Also contributing to the accident was the Federal Aviation Administration's failure to implement the pilot records database in a sufficiently robust and timely manner.

Safety Issues

The investigation evaluated the following safety issues:

- **Inadvertent activation of the go-around mode.** The investigation determined a likely scenario to explain how the go-around mode became activated. However, a review of the available data suggests that inadvertent activation of the go-around mode on Boeing 767-series airplanes may be a rare and typically benign event;

- **Flight crew performance.** The investigation examined the factors that influenced the FO's incorrect response following the unexpected mode change and the captain's delayed awareness of and ineffective response to the situation;

- **Atlas' evaluation of the FO.** The FO failed to disclose to Atlas some of the training difficulties he experienced at former employers, and Atlas' records review did not identify the FO's past training failure at one former employer, which may have affected how Atlas evaluated him during the hiring process and during training;

- **Industry pilot hiring process deficiencies.** Limitations in the background records retrieval process places hiring operators (like Atlas when considering the FO's application) at a disadvantage when trying to obtain a complete training history on a pilot applicant. Also, the circumstances of this accident highlighted a need for improved pilot selection and performance measurement methods;

- **Awareness information for Boeing 767 and 757 pilots.** Although there were no other known events involving inadvertent activation of the go-around mode on a Boeing 767-series airplane, pilots of Boeing 767- and 757-series airplanes (which share a similar go-around switch design) could benefit from understanding the circumstances of this accident;

- **Adaptations of automatic ground collision avoidance technology.** The US military has successfully equipped some fighter airplanes with an automatic ground collision avoidance system that has prevented the loss of several aircraft and saved lives. Research into adapting such technology for lower-performance, less-maneuverable airplanes could have relevance for civil transport-category airplanes; and

- **Cockpit image recorders.** Certain aspects of the circumstances of this accident could be better known with improved information about flight crew actions, possibly leading to additional safety recommendations for preventing similar accidents.

Findings

- None of the following were factors in this accident: (1) the captain's and the first officer's certifications and qualifications; (2) air traffic control services; (3) the condition and maintenance of airplane structures, powerplants, and systems; and (4) airplane weight and balance.

- There was insufficient information to determine whether the flight crewmembers were fatigued at the time of the accident, and no available evidence suggested impairment due to any medical condition, alcohol, or other impairing drugs.

- Whatever electronic flight instrument system display anomaly the first officer (FO) experienced was resolved to both crewmembers' satisfaction (by the FO's cycling of the electronic flight instrument switch) before the events related to the accident sequence occurred.

- The activation of the airplane's go-around mode was unintended and unexpected by the pilots and occurred when the flight was encountering light turbulence and likely instrument meteorological conditions associated with its penetration of the leading edge of a cold front.

- Presuming that the first officer (FO) was holding the speedbrake lever as expected in accordance with Atlas Air Inc.'s procedure, the inadvertent activation of the go-around mode likely resulted from unintended contact between the FO's left wrist or watch and the left go-around switch due to turbulence-induced loads that moved his arm.

- Despite the presence of the go-around mode indications on the flight mode annunciator and other cues that indicated that the airplane had transitioned to an automated flight path that differed from what the crew had been expecting, neither the first officer nor the captain were aware that the airplane's automated flight mode had changed.

- Given that the first officer (FO) was the pilot flying and had not verbalized any problem to the captain or initiated a positive transfer of airplane control, the manual forward elevator control column inputs that were applied seconds after the inadvertent activation of the go-around mode were likely made by the FO.

- The first officer likely experienced a pitch-up somatogravic illusion as the airplane accelerated due to the inadvertent activation of the go-around mode, which prompted him to push forward on the elevator control column.

- Although compelling sensory illusions, stress, and startle response can adversely affect the performance of any pilot, the first officer had fundamental weaknesses in his flying aptitude and stress response that further degraded his ability to accurately assess the airplane's state and respond with appropriate procedures after the inadvertent activation of the go-around mode.

- Had the Federal Aviation Administration met the deadline and complied with the requirements for implementing the pilot records database (PRD) as stated in Section 203 of the *Airline Safety and Federal Aviation Administration Extension Act of 2010*, the PRD would have provided hiring employers relevant information about the first officer's employment history and training performance deficiencies.

- The first officer's long history of training performance difficulties and his tendency to respond impulsively and inappropriately when faced with an unexpected event during training scenarios at multiple employers suggest an inability to remain calm during stressful situations—a tendency that may have exacerbated his aptitude-related performance difficulties.

- While the captain was setting up the approach and communicating with air traffic control, his attention was diverted from monitoring the airplane's state and verifying that the flight was proceeding as planned, which delayed his recognition of and response to the first officer's unexpected actions that placed the airplane in a dive.

- The captain's failure to command a positive transfer of control of the airplane as soon as he attempted to intervene on the controls enabled the first officer to continue to force the airplane into a steepening dive.

- The captain's degraded performance, which included his failure to assume positive control of the airplane and effectively arrest the airplane's descent, resulted from the ambiguity, high stress, and short timeframe of the situation.

- The first officer's repeated uses of incomplete and inaccurate information about his employment history on resumes and applications were deliberate attempts to conceal his history of performance deficiencies and deprived Atlas Air Inc. and at least one other former employer of the opportunity to fully evaluate his aptitude and competency as a pilot.

- Atlas Air Inc.'s human resources personnel's reliance on designated agents to review pilot background records and flag significant items of concern was inappropriate and resulted in the company's failure to evaluate the first officer's unsuccessful attempt to upgrade to captain at his previous employer.

- Operators that rely on designated agents or human resources personnel for initial review of records obtained under the Pilot Records Improvement Act should include flight operations subject matter experts early in the records review process.

- The manual process by which Pilot Records Improvement Act records are obtained could preclude a hiring operator from obtaining all background records for a pilot applicant who fails to disclose a previous employer due to either deception or having resigned before being considered fully employed, such as after starting but not completing initial training.

- The establishment of a confidential voluntary data clearinghouse to share deidentified pilot selection data among airlines about the utility of different methods for predicting pilot success in training and on the job would benefit the safety of the flying public.

- All pilots of Boeing 767- and 757-series airplanes (which share a similar go-around switch design) could benefit from an awareness of the circumstances of this accident that likely led to the inadvertent activation of the go-around mode.

- The Department of Defense has developed approaches to automatic ground collision avoidance system technology for fighter airplanes that, if successfully adapted for use in lower-performance, less-maneuverable airplanes, could serve as a model for the development of similar installations in civil transport-category airplanes that could dramatically reduce terrain collision accidents involving pilot spatial disorientation.

- An expanded data recorder that records the position of various knobs, switches, flight controls, and information from electronic displays, as specified in amendment 43 to the recorder standards of the International Civil Aviation Organization, would not have provided pertinent information about the flight crew's actions.

- A flight deck image recording system compliant with Technical Standard Order TSO-C176a, "Cockpit Image Recorder Equipment," would have provided relevant information about the data available to the flight crew and the flight crew's actions during the accident flight.

Recommendations

New Recommendations

To the Federal Aviation Administration

- Inform Title 14 Code of Federal Regulations Part 119 certificate holders, air tour operators, fractional ownership programs, corporate flight departments, and governmental entities conducting public aircraft operations about the hiring process vulnerabilities identified in this accident, and revise Advisory Circular 120-68H, "Pilot Records Improvement Act and Pilot Records Database," to emphasize that operators should include flight operations subject matter experts early in the records review process and ensure that significant training issues are identified and fully evaluated. (A-20-33)

- Implement the pilot records database and ensure that it includes all industry records for all training started by a pilot as part of the employment process for any Title 14 *Code of Federal Regulations* Part 119 certificate holder, air tour operator, fractional ownership program, corporate flight department, or governmental entity conducting public aircraft operations regardless of the pilot's employment status and whether the training was completed. (A-20-34)

- Ensure that industry records maintained in the pilot records database are searchable by a pilot's certificate number to enable a hiring operator to obtain all background records for a pilot reported by all previous employers. (A-20-35)

- Establish a confidential voluntary data clearinghouse of deidentified pilot selection data that can be used to conduct studies useful for identifying effective, scientifically based pilot selection strategies. This program should be modeled after programs like Aviation Safety Information and Analysis Sharing and Flight Operations Quality Assurance. (A-20-36)

- Issue a safety alert for operators to inform pilots and operators of Boeing 767- and 757-series airplanes about the circumstances of this accident and alert them that, due to the close proximity of the speedbrake lever to the left go-around mode switch, it is possible to inadvertently activate the go-around mode when manipulating or holding the speedbrake lever as a result of unintended contact between the hand or wrist and the go-around switch. (A-20-37)

- Convene a panel of aircraft performance, human factors, and aircraft operations experts to study the benefits and risks of adapting military automatic ground collision avoidance system technology for use in civil transport-category airplanes and make public a report on the committee's findings. (A-20-38)

Previously Issued Recommendations Reiterated and Classified in this Report

To the Federal Aviation Administration:

- Require all Part 121 and 135 air carriers to obtain any notices of disapproval for flight checks for certificates and ratings for all pilot applicants and evaluate this information before making a hiring decision. (A-05-1) Classified "Open—Unacceptable Response"

- Require 14 *Code of Federal Regulations* Part 121, 135, and 91K operators to document and retain electronic and/or paper records of pilot training and checking events in sufficient detail so that the carrier and its principal operations inspector can fully assess a pilot's entire training performance. (A-10-17) Classified "Open—Unacceptable Response"

- Require 14 *Code of Federal Regulations* Part 121, 135, and 91K operators to provide the training records requested in Safety Recommendation A-10-17 to hiring employers to fulfill their requirement under the Pilot Records Improvement Act. (A-10-19) Classified "Open—Unacceptable Response"

- Develop a process for verifying, validating, auditing, and amending pilot training records at 14 *Code of Federal Regulations* Part 121, 135, and 91K operators to guarantee the accuracy and completeness of the records. (A-10-20) Classified "Open—Unacceptable Response"

Previously Issued Recommendations Reiterated in this Report

To the Federal Aviation Administration:

- Require that all existing aircraft operated under Title 14 *Code of Federal Regulations* (*CFR*) Part 121 or 135 and currently required to have a cockpit voice recorder and a flight data recorder be retrofitted with a crash-protected cockpit image recording system compliant with Technical Standard Order TSO-C176a, "Cockpit Image Recorder Equipment," TSO-C176a or equivalent. The cockpit image recorder should be equipped with an independent power source consistent with that required for cockpit voice recorders in 14 *CFR* 25.1457. (A-15-7)

- Require that all newly manufactured aircraft operated under Title 14 *Code of Federal Regulations* (*CFR*) Part 121 or 135 and required to have a cockpit voice recorder and a flight data recorder also be equipped with a crash-protected cockpit image recording system compliant with Technical Standard Order TSO-C176a, "Cockpit Image Recorder Equipment," or equivalent. The cockpit image recorder should be equipped with an independent power source consistent with that required for cockpit voice recorders in 14 *CFR* 25.1457. (A-15-8)

1. Factual Information

1.1 History of Flight

On February 23, 2019, at 1239 central standard time, Atlas Air Inc. (Atlas) flight 3591, a Boeing 767-375BCF, N1217A, was destroyed after it rapidly descended from an altitude of about 6,000 ft mean sea level (msl) and crashed into a shallow, muddy marsh area of Trinity Bay, Texas, about 41 miles east-southeast of George Bush Intercontinental/Houston Airport (IAH), Houston, Texas.[1] The captain, first officer (FO), and a nonrevenue pilot riding in the jumpseat died. Atlas operated the airplane as a Title 14 *Code of Federal Regulations* (*CFR*) Part 121 domestic cargo flight for Amazon.com Services LLC, and an instrument flight rules flight plan was filed. The flight departed from Miami International Airport (MIA), Miami, Florida, about 1033 (1133 eastern standard time) and was destined for IAH.

A review of cockpit voice recorder (CVR) and flight data recorder (FDR) data determined that the flight's departure from MIA, en route cruise, and initial descent toward IAH were uneventful. The FO was the pilot flying (PF), the captain was the pilot monitoring (PM), and automated flight functions (autopilot and autothrottle) were engaged. At 1230:37, when the flight was about 73 miles southeast of IAH and descending normally through about 17,800 ft msl, the captain checked in with the Houston terminal radar approach controller and reported that the flight was descending toward the airport on the assigned arrival route. At 1234:09, the approach controller advised the flight crew of an area of light-to-heavy precipitation about 35 miles ahead of the flight's position and that they could expect vectors to navigate around it.

The FDR data showed the flight continued to descend normally on the assigned arrival route. According to CVR audio, at 1236:07, the FO said, "okay – I just had a…," then, 3 seconds later, he initiated a positive transfer of airplane control to transfer PF duties to the captain, stating, "your controls."[2] The captain responded, "my controls." At 1237:07, the FO made a comment about the electronic flight instrument (EFI) switch.[3] Two seconds later, the FO said, "okay, I got it back," and the captain said, "now it's back." The FO then said, "I press the EFI button, it fixes everything," and the captain acknowledged.

[1] (a) All times in this report are central standard time unless otherwise noted. (b) Supporting documentation for information referenced in this report can be found in the public docket for this accident, which can be accessed from the National Transportation Safety Board's (NTSB) Accident Dockets web page by searching DCA19MA086. Other NTSB documents referenced in this report, including reports and summarized safety recommendation correspondence, can be accessed from the NTSB's Aviation Information Resources web page.

[2] In this report, times for information from the CVR and FDR are rounded to the nearest second, and quoted excerpts from the CVR transcript and other documents (such as procedures manuals) may contain punctuation, capitalization, or other minor editorial style revisions. See appendix D for the unrevised CVR transcript or the public docket for other source documents. See section 1.9.1.1 for more information about Atlas' procedures for positive transfer of airplane control.

[3] The EFI switch is used to resolve certain electronic flight instrument system display anomalies (see section 1.3.1.2).

While acting as PM, the FO advised the air traffic controller that the flight would like a vector west of the weather and acknowledged the controller's instructions for the flight to "hustle all the way down" in its descent to 3,000 ft msl.[4] As the airplane continued its descent, the speedbrakes were extended.[5] The controller advised the flight to turn left to 270°, which the captain acknowledged before transferring PF duties back to the FO at 1237:24.

After the FO resumed PF duties, the CVR recorded comments between the FO and the captain that were consistent with setting up the flight management computer (FMC) and configuring the airplane for the approach to IAH, including lowering the slats (consistent with the "flaps 1" setting). The FDR data showed that the airplane continued to descend normally until 1238:31, when the airplane's go-around mode was activated.[6] At the time, the airplane was about 40 miles from IAH at an altitude about 6,300 ft msl.

During the next 6 seconds, the airplane's automated flight functions commanded nose-up pitch and an increase in engine thrust, consistent with go-around mode-driven commands. Neither crewmember made any callout to indicate intentional activation of the go-around mode or took action to disconnect the automation. The captain continued to receive and respond to routine air traffic control (ATC) communications.

About 1238:36, the speedbrakes were retracted, then the airplane's elevators moved in response to manual control inputs to command nose-down pitch.[7] The amount of nose-down pitch continued to increase, and the airplane entered a steep descent. Beginning at 1238:44, the FO said, "oh," then said in an elevated voice "whoa… (where's) my speed, my speed…we're stalling;" he then exclaimed "stall" at 1238:51. A review of FDR data determined that the airplane's airspeed and pitch parameters were not consistent with the airplane at (or near) a stalled condition, and none of the stall warning system indications activated.

At 1238:56, the captain asked, "what's goin' on?" Three seconds later, the pilot riding in the jumpseat shouted, "pull up." About this time, the elevators moved consistent with manual control inputs to command airplane nose-up pitch. The nose-up pitch control inputs were held for the remaining 7 seconds of the flight but were unsuccessful in arresting the airplane's descent in time to prevent its crash into the marsh (see figure 1).

[4] When the FO requested a vector west of the weather, the controller advised that departing traffic would be headed toward the flight on that side. According to the controller, he issued the expedited descent instructions to ensure that the accident flight would pass under the departing traffic.

[5] Speedbrakes (or spoilers) are devices on each wing that reduce lift and increase drag when deployed.

[6] Go-around mode is typically used when an airplane is on approach to landing and the flight crew chooses to reject the landing and go around for another attempt. Generally, a crewmember would announce its use with a "go around" callout before pushing one of the go-around activation switches (one located on each thrust lever). Based on the accident airplane's settings at the time, activating the go-around mode would result in an automatic advance in the thrust levers and an automatic increase in nose-up pitch to arrest the airplane's descent and transition into a climb. See section 1.8.1 for more information about the accident airplane's responses at this point in the accident sequence.

[7] On the accident airplane, manual control inputs could override automated flight functions but would not disconnect the automation.

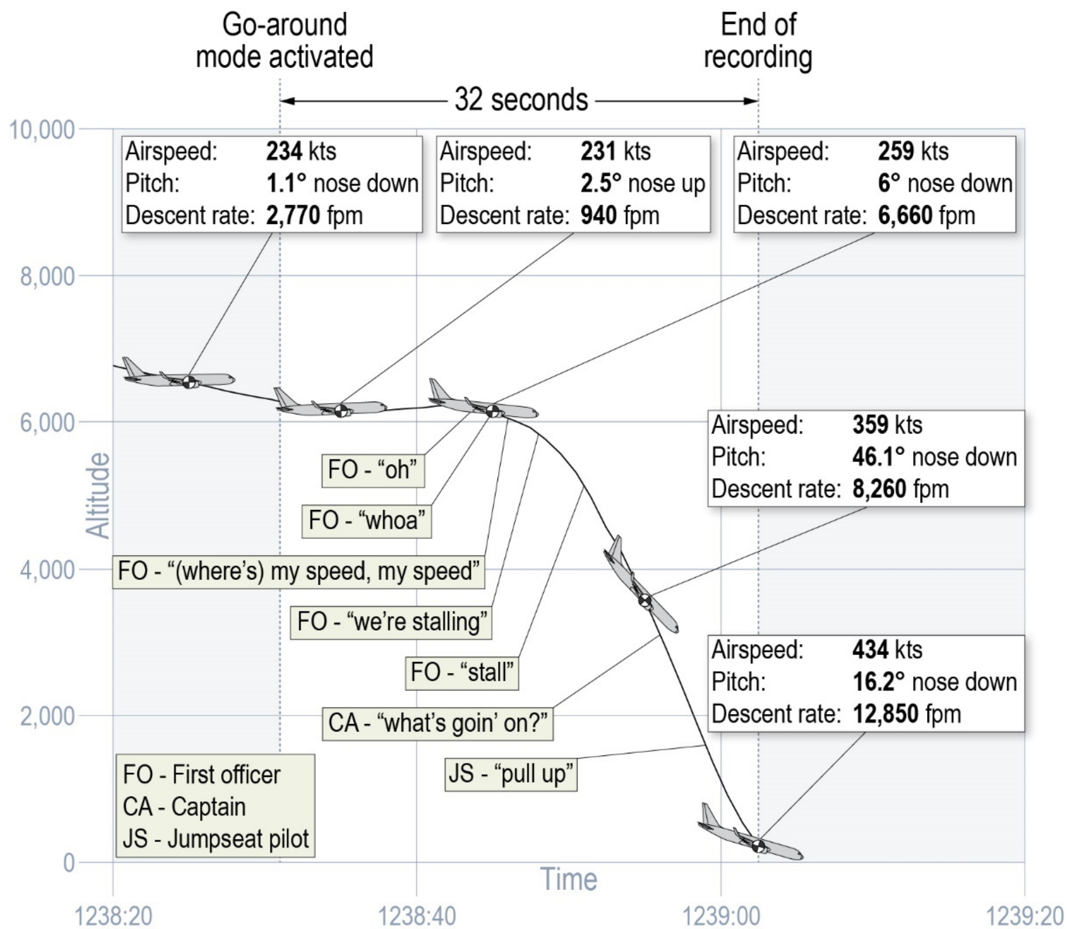

Figure 1. Selected airplane parameters and crew statements during final seconds of flight.[8]

1.2 Personnel Information

1.2.1 Captain

The captain, age 60, held an airline transport pilot (ATP) certificate with type ratings for Boeing 757, Boeing 767, and Embraer ERJ145 airplanes.[9] His first-class airman medical certificate was issued September 6, 2018, with the limitation, "must wear corrective lenses."

The captain was hired by Atlas as an FO on September 7, 2015, and he upgraded to captain on the Boeing 767 on August 25, 2018. At the time of the accident, the captain had accumulated about 11,172 hours of total flying time, of which 4,235 hours were as pilot-in-command (PIC). He had a total of 1,252 hours of flying time in Boeing 767-series airplanes, of which 157 hours were

[8] Altitude, indicated airspeed, and pitch are FDR-recorded parameters. Vertical speed is a calculated parameter.

[9] The captain also held a flight instructor certificate with ratings for single-engine, multiengine, and instrument airplanes.

as PIC. In the 90 days, 30 days, and 24 hours before the accident, the captain had accumulated a total of 100 hours, 34 hours, and about 2.5 hours of flying time, respectively.

Information about the captain's sleep and activities in the 72 hours before the accident was limited.[10] The day before the accident, he worked a night shift with the FO from 0157 to 0831. On the day of the accident, his workday (a day shift) began at 0838.

1.2.1.1 Training History at Atlas

The captain completed basic indoctrination training on September 11, 2015, and Boeing 767 ground school on September 27, 2015. He received training (that included stall training) in a Boeing 767 full-flight simulator between October 16 and 30, 2015.

On October 31, 2015, the captain (while an FO) was not recommended for his Boeing 767 type-rating checkride after he allowed the airplane's airspeed to exceed the specified limitation for the flaps during stall recovery, consistently failed to set the missed approach altitude, and had problems performing missed approach procedures. He satisfactorily completed remedial training the next day, which included speed awareness during recovery from approaches to a stall. On November 2, 2015, he completed his Boeing 767 type-rating checkride, which included an evaluation of a takeoff stall during a turn.

As a result of the October 2015 training failures associated with the captain (as an FO) not being recommended for the type-rating checkride, Atlas placed the captain in the pilot proficiency watch program (PWP) from November 11, 2015, until February 22, 2017.[11] He completed recurrent training for the Boeing 767 on February 25, 2016, which included three stalls (takeoff, landing, and clean configurations), and proficiency checks on May 19, 2016, and September 5, 2016, each of which included one takeoff stall in a turn.

The captain (while an FO) completed a proficiency check on August 12, 2017, which included one takeoff stall in a turn, and recurrent simulator training on March 7, 2017, and March 4, 2018, each of which included three stalls.

On August 12, 2018, the captain (while an FO) completed Boeing 767 captain-upgrade ground training, which included a 2-hour module on crew resource management (CRM, as required by 14 *CFR* 121.427) and an 8-hour module on captain leadership. He completed upgrade systems training on August 15, 2018, and was recommended for captain upgrade on August 23, 2018, after completing five upgrade training sessions in the full-flight simulator. He passed a captain proficiency check on August 25, 2018.

From September 18 through October 16, 2018, the captain completed initial operating experience as captain on the Boeing 767. The captain also passed a line check on October 11, 2018.

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[10] Family members of the captain contacted by investigators did not provide any information about his recent activities.

[11] See sections 1.9.2.1 and 1.9.2.2 for more information on Atlas' PWP and the captain's participation in the PWP.

He completed his most recent Boeing 767 captain recurrent training on February 9, 2019, during a line-oriented flight training simulator session.

1.2.1.2 Certificate History and Previous Employment

Federal Aviation Administration (FAA) records for the captain showed no reports of any previous aviation accidents or incidents and no notices of disapproval on his certificates and ratings.

The captain's previous employment, which he disclosed to Atlas when he applied for a job there, included the following:

- ExpressJet (July 2005 until hired by Atlas): Embraer ERJ145 captain
- CommutAir (September 2003 to July 2005): Beechcraft 1900D FO
- FlightSafety International (March 2002 to September 2003): Flight instructor

1.2.2 First Officer

The FO, age 44, held an ATP certificate with type ratings for Boeing 757 and 767 airplanes and Embraer EMB120, ERJ145, ERJ170, and ERJ190 airplanes. His first-class airman medical certificate was issued November 29, 2018, with the limitation, "must have available glasses for near vision."

The FO was hired by Atlas on July 3, 2017, and transitioned to and received his initial type rating on the Boeing 767 on September 26, 2017. At the time of the accident, the FO had accumulated about 5,073 hours total flying time, of which 1,237 hours were as PIC. He had accumulated a total of 520 hours of flying time as second-in-command in Boeing 767-series airplanes. In the 90 days, 30 days, and 24 hours before the accident, the FO had accumulated a total of 106 hours, 34 hours, and about 2.5 hours of flying time, respectively.

Information about the FO's sleep and activities in the 72 hours before the accident was limited.[12] The day before the accident, he worked a night shift with the captain from 0157 to 0831. On the day of the accident, his workday (a day shift) began at 0838.

1.2.2.1 Training History at Atlas

The FO completed Atlas basic indoctrination training on July 7, 2017, and Boeing 767 ground school on July 22, 2017. On July 27, 2017, he was not recommended for his Boeing 767 type-rating oral examination due to his need for remedial training in takeoff and landing performance and airplane systems. He completed 4.5 hours of remedial training, which included

[12] Neither the FO's girlfriend nor a family member contacted by investigators provided any information about his recent activities.

takeoff and landing performance and aircraft systems, then passed the oral examination on July 29, 2017. The FO was recommended to begin Boeing 767 fixed-base simulator training the next day. After completing five fixed-base simulator training sessions, the FO was not recommended to proceed to full-flight simulator training due to his difficulty in completing normal procedures. The FO received one 4-hour remedial training session then completed fixed-base training on August 8, 2017.

According to the fleet captain, the FO began full-flight simulator training for the Boeing 767 on August 10, 2017, and, after two sessions, the FO's simulator partner complained that he was being held back by the FO. The fleet captain said that, at the time, Atlas did not have the available seat support to continue the FO's full-flight simulator training and decided to restart it from the beginning on August 27, 2017.

By September 3, 2017, the FO had completed his sixth full-flight simulator training session when the effects of a hurricane forced Atlas to shut down all training for several days. The FO's training resumed on September 19, 2017. On September 22, 2017, the FO failed his practical Boeing 767 type-rating examination due to unsatisfactory performance in CRM, threat and error management, nonprecision approaches, steep turns, and judgment. During a postaccident interview, the Atlas check airman who was the FO's examiner said the FO was very nervous, had "very low" situational awareness, overcontrolled the airplane, did not work well with the other pilot, omitted an emergency checklist during an abnormal event, and exceeded a flap speed. The examiner said the FO was not thinking ahead, and, when he realized that he needed to do something, he often did something inappropriate, like push the wrong button. The examiner said the FO's performance was so poor that he worried that the FO would be unable to "mentally recover" enough to complete the course.

The FO received remedial training on September 25, 2017, and he passed the type-rating checkride the next day. During a postaccident interview, the Atlas instructor who performed the FO's remedial training (who was not the same person as the checkride examiner) said he thought the FO had a confidence problem and described the remedial training as a "great training session." The FO was not placed in the PWP.[13] Between October 26 and November 22, 2017, the FO received 53 hours of initial operating experience on the Boeing 767 and, by January 24, 2018, had completed 116 hours of Boeing 767 flight time. He completed recurrent line-oriented flight training on February 17, 2018, and January 7, 2019.

The FO completed his most recent recurrent ground school training on July 7, 2018, and completed his most recent recurrent simulator proficiency check the next day. In both instances, he was graded satisfactory/complete on unusual attitudes, upset recovery maneuvers, and a takeoff stall recovery.

[13] See sections 1.9.2.1 and 1.9.2.2 for more information on Atlas' PWP and the FO's participation in the PWP.

1.2.2.2 Certificate History and Previous Employment

FAA records for the FO showed no reports of any previous aviation accidents or incidents. Records for the FO's pilot certificates showed the following notices of disapproval (and subsequent certificate issuances after he passed retests):

- ATP Boeing 767, practical test failure (September 22, 2017): Takeoff and departure phase, in-flight maneuvers. Certificate issued 4 days later.
- ATP Embraer ERJ145, practical test failure (May 11, 2014): Nonprecision approaches, navigation procedures. Certificate issued the next day with a PIC limitation. The limitation was removed on September 30, 2014.
- ATP Embraer ERJ145, oral examination failure (April 22, 2014): Retest completed 4 days later.

The FO's previous employment included the following:

- Mesa Airlines (February 2015 until July 2017, when he was hired by Atlas): Embraer ERJ175 FO, unsuccessfully attempted to upgrade to captain in May 2017 and resigned (citing "career growth") to accept a position with Atlas.
- Trans States Airlines (March to September 2014): Embraer ERJ145 FO, failed an oral examination for the Embraer ERJ145 in April (then successfully retested) and failed Embraer ERJ145 ATP checkride in May (then successfully received his certificate). He was graded unsatisfactory on a line check in August and resigned citing personal reasons.
- Charter Air Transport (February 2013 to March 2014): Embraer EMB120 FO.
- Air Wisconsin Airlines (April to August 2012): Did not complete FO initial training for Canadair Regional Jet and resigned citing personal reasons.
- CommutAir (May to June 2011): Did not complete FO initial training for de Havilland DHC-8 and resigned citing "lack of progress in training."
- Air Turks and Caicos (June 2008 to June 2010): Embraer EMB120 FO until furloughed.

When the FO applied for a job at Atlas, he did not disclose that he had worked for Air Wisconsin and CommutAir or that he did not complete initial training at either airline. He also did not disclose to Trans States Airlines when he applied for a job there that he had previously worked for and did not complete initial training at Air Wisconsin. Investigative interviews with instructors who evaluated the FO at two of his previous employers provided insight into the FO's training performance at those airlines.

According to one check airman at Mesa Airlines, the FO could explain things well in the briefing room and performed some expected tasks well in the simulator. However, when presented with something unexpected in the simulator, the FO would get extremely flustered and could not respond appropriately to the situation. She said that when the FO did not know what to do, he became extremely anxious and would start pushing a lot of buttons without thinking about what he was pushing, just to be doing something. She noted that the FO lacked an understanding of how unsafe his actions were, and he could not see why he should not be upgraded to a captain.

Another check airman at Mesa said the FO's stick and rudder skills were weak, and he also struggled with basic flight management system tasks. This check airman described the FO's piloting performance as among the worst he had ever seen and noted that the FO tended to have an excuse for each of his poor performances, such as blaming his simulator partner, his instructor, or the hotel. A third check airman at Mesa said that the FO had weak situational awareness, did not realize what was going on with the airplane at times, and had difficulty staying ahead of the airplane. She said the FO was completely unaware that he lacked skills, unwilling to accept feedback, and unhappy with her about his failure to upgrade to captain.

An instructor who taught cockpit procedures on the flight training devices at Air Wisconsin Airlines recalled that during one emergency procedures training scenario, the FO made abrupt control inputs that triggered the stick shaker and overspeed alerts. The instructor said that instead of staying engaged in the scenario and addressing the problem with his training partner, the FO just stopped what he was doing and turned around and looked at the instructor. The instructor found this reaction highly unusual.

1.3 Airplane Information

The accident airplane was a Boeing 767-375BCF (Boeing Converted Freighter), which was manufactured in 1992 in a passenger configuration and was converted for cargo operations in 2017. Atlas placed the airplane on its operating certificate in 2017. It was equipped with two General Electric CF6-80C2B6F turbofan engines that were installed on the airplane in 2017 and a Honeywell auxiliary power unit. The airplane was leased to Amazon.com Services LLC and was painted in Amazon's Prime Air (later renamed Amazon Air) livery (see figure 2).

Source: Jehan M. Ghouse, www.airliners.net

Figure 2. Photograph of accident airplane.

The cockpit was configured with four jumpseats, one directly behind the flight crew seats (to the right of center, closer to the FO's seat) and three in a row farther aft. The airplane's cargo area was divided into four compartments. The main deck, lower forward, and lower aft cargo compartments were equipped with floor lock assemblies and could accommodate cargo secured on pallets or in containers. The bulk cargo compartment (which was empty for the accident flight) could accommodate cargo placed on the floor.

Atlas maintained the airplane under a continuous airworthiness maintenance program that was monitored under its FAA-approved continuing analysis and surveillance system and reliability program. Reviews of the records for the most recent completion of the interval check items for the airplane (flight hour, flight cycle, and calendar time-sensitive items) revealed no unresolved items or discrepancies. Reviews of Atlas' records for various airworthiness directives applicable to the airplane revealed no discrepancies. The airplane had no open minimum equipment list items on the day of the accident.

As of the day of the accident, the airplane had accumulated 91,063 total flight hours with 23,316 total flight cycles. The left and right engines had accumulated 109,590 and 107,540 total operating hours, respectively, and the auxiliary power unit had accumulated 48,443 total operating hours.

A review of weight and balance and loading information for the accident flight revealed the airplane was within weight and center-of-gravity limits. The cargo was loaded within the structural limitations for each respective compartment and included no hazmat or dangerous goods. The accident airplane's takeoff weight was 249,519 lbs (its maximum certificated takeoff weight was 408,483 lbs).

1.3.1 Electronic Flight Instrument System

1.3.1.1 General

The airplane's electronic flight instrument system (EFIS) included displays on the left and right sides of the cockpit (for the captain and FO, respectively) that provided visual presentations of information derived from numerous systems, including instrument landing system (ILS) receivers and radio altimeters. Each pilot's display included a horizontal situation indicator (HSI) and an attitude director indicator (ADI), among other features.

Each HSI provided an electronically generated color presentation of navigational information that could show the airplane's position on a dynamic map. Each ADI provided presentations for airplane attitude (pitch and roll), a pitch limit indicator, flight director commands, localizer and glideslope deviations, automated flight mode annunciations, airspeed (using an airspeed tape), radio altitude, and decision height (see figure 3).[14]

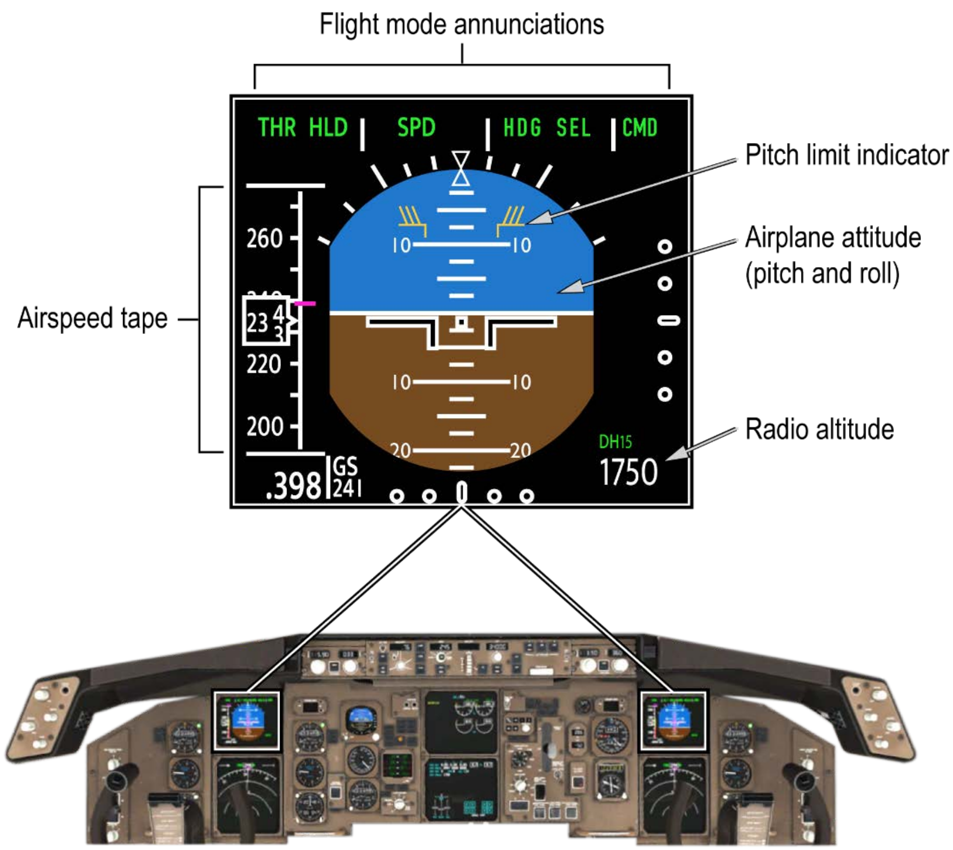


Figure 3. Exemplar ADI with select features labeled.

[14] The pitch limit indicator, which was a function of the stall warning computer and available when the airplane's flaps were extended, showed what airplane pitch attitude would coincide with stick shaker activation.

The airspeed tape had specific indicators to identify various airspeed limitations, such as a red bar for the minimum operating speed (emanating from the bottom) or the maximum speed (emanating from the top), an amber bracket to show the range of minimum maneuvering speeds, and a green trend vector arrow to indicate predicted airspeed in 10 seconds based on current acceleration or deceleration (see figure 4).[15]

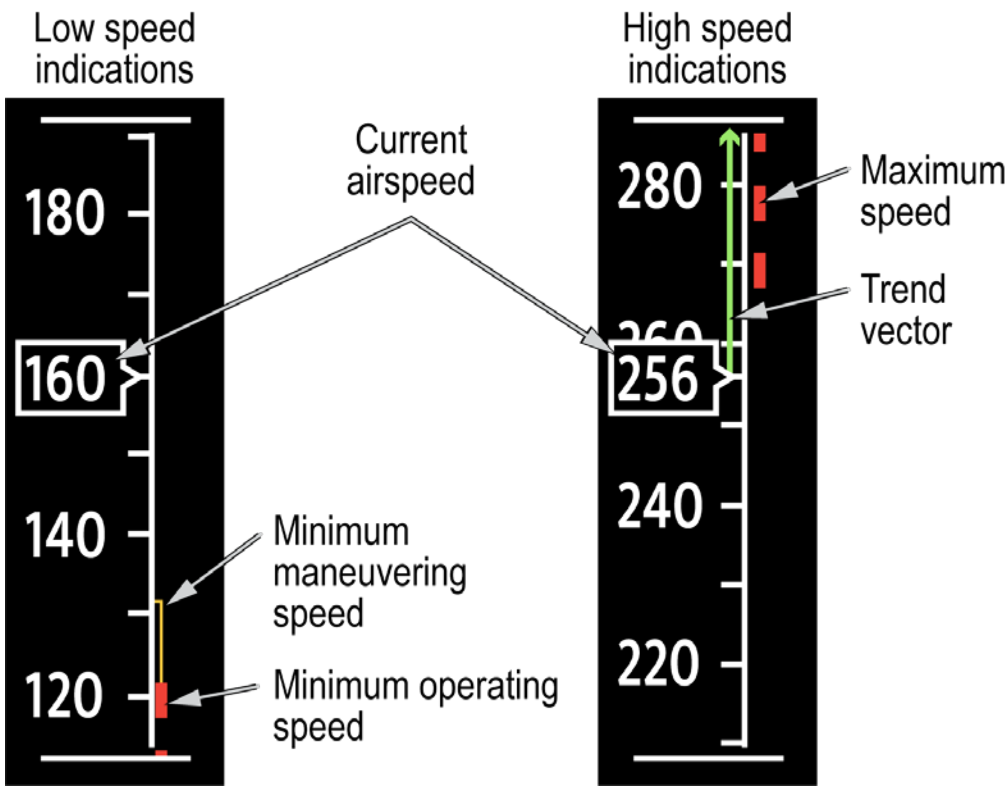


Figure 4. Exemplar airspeed tape indications.

The instrument panel was also equipped with two conventional Mach/airspeed indicators, one on each side of the cockpit, that displayed airspeed information from the selected air data source. Each of these airspeed indicators included a “barber pole” to show the maximum operating speed (V_{mo}) (see figure 5).

[15] The maximum speed bar indicated the maximum permissible airspeed as limited by the lowest of the maximum operating speed (V_{mo}), landing gear placard speed, or flap placard speed. The minimum operating speed indicated the airspeed at which the stick shaker would activate (when the airplane was operating below 20,000 ft).

Figure 5. Exemplar conventional airspeed indicator.

1.3.1.2 Electronic Flight Instrument Switch

As described in section 1.1, at 1237:07, the FO made a comment about the EFI switch, which a pilot could use to select the sources of information that support each respective EFIS display. The left (captain's) EFIS displays were normally supported by the left symbol generator (SG), left ILS receiver, and left radio altimeter, and the right (FO's) EFIS displays were normally supported by the right SG, right ILS receiver, and right radio altimeter.[16] The EFIS was also equipped with a center SG, center ILS receiver, and center radio altimeter, which could be used, if needed, as alternate sources of information for the left and/or right displays. Each side of the cockpit was equipped with an EFI switch to enable the captain and FO to independently select between the normal and alternate sources for their respective displays (figure 6 shows an EFI switch on the right side of an exemplar cockpit).

[16] The SGs receive inputs from various airplane systems and then use those data to generate the proper visual displays for the respective ADI and HSI.

Note: Red box added to show location.

Figure 6. EFI switch on right side of an exemplar cockpit.

During normal operations, each EFI switch would be in the "normal" position (no white light showing on the switch), and the left and right cockpit displays would each use their respective side's SG, ILS, and altimeter as sources of information. Pushing an EFI switch to the "alternate" position (white light showing on the switch) would power off the respective display's normal SG, ILS, and altimeter group and instead use the center SG, ILS, and altimeter as sources of information.

Based on information provided by Rockwell Collins, the EFIS manufacturer, a pilot could clear an intermittent display blanking and reset the affected SG by cycling the EFI switch from normal to alternate and back. A display fault involving a loss of parametric data to the SG, which would be indicated by a red fault indication or flag on the affected display, could be resolved by pushing the EFI switch to select the alternate (center SG, ILS, and altimeter) sources.

According to Atlas instructors and check airmen interviewed, use of the EFI switch was a systems knowledge item that was trained as a non-normal event in the simulator and was suggested as a non-normal event for use during Boeing 767 type-rating checkrides.[17] There was no checklist item associated with its use.

[17] Generally, a non-normal event involves a single, well-isolated malfunction that presents a lower level of risk to flight safety than an emergency event (Burian, Barshi, and Dismukes 2005, 2).

1.3.2 Go-Around Switches

The airplane's go-around switches were located on the outboard underside of each thrust lever. Internally, each go-around switch contained a set of three microswitch contacts that provided discrete inputs to various computers for the automated flight system. To activate the go-around mode, a pilot would typically use the thumb of the hand that is holding the thrust levers to push the nearest switch.[18] The speedbrake lever was located to the left of the thrust levers (see figure 7).

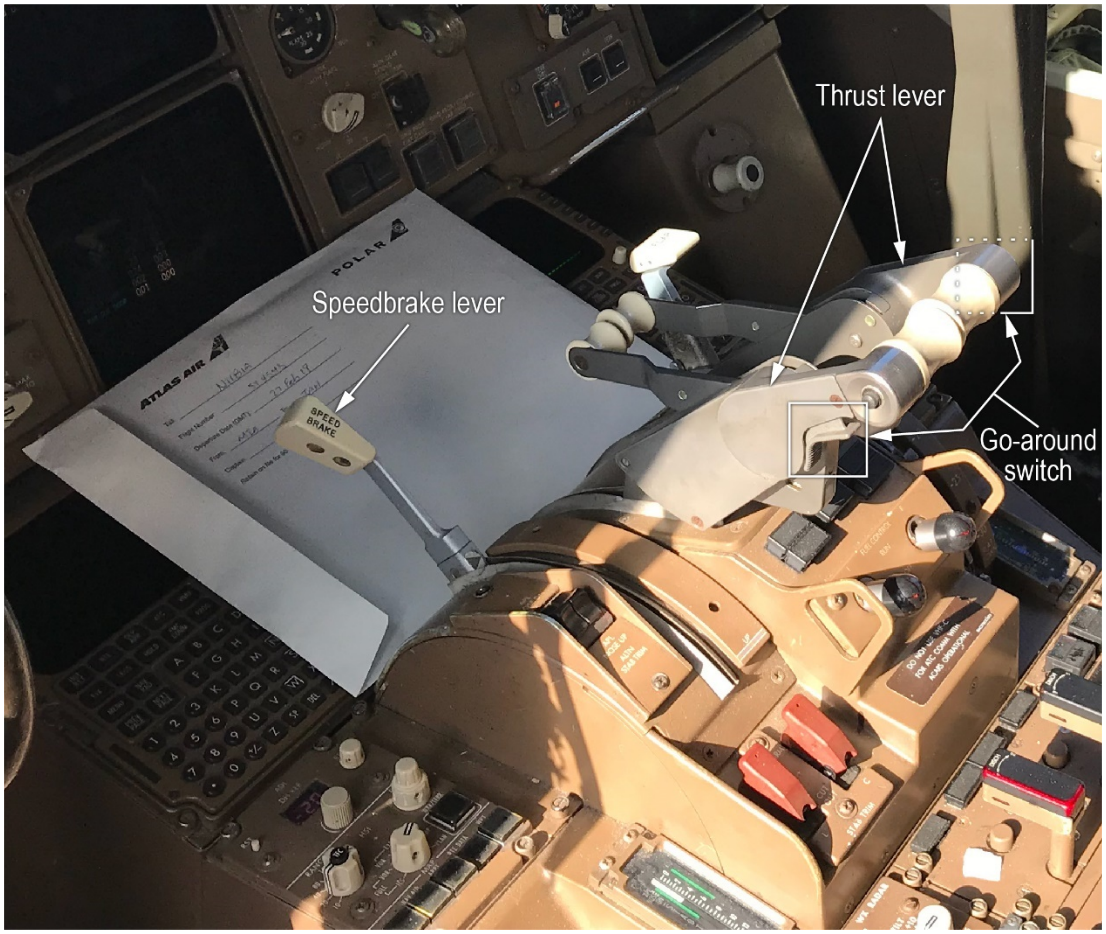


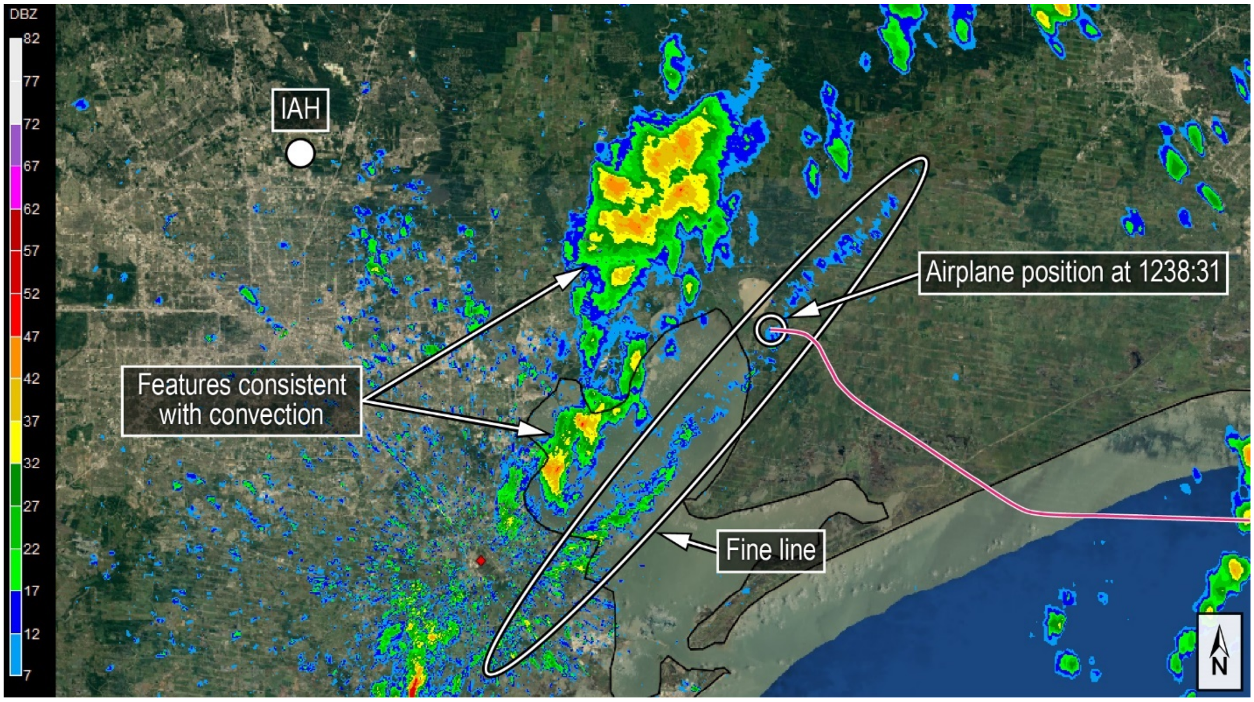
Figure 7. Locations of thrust levers, go-around switches, and speedbrake lever in an exemplar Boeing 767 airplane.

1.4 Meteorological Information

As the flight approached IAH from the southeast, a cold front was advancing to the southeast over Trinity Bay. The cold front extended from Arkansas through far southern Texas and was located between the airplane and IAH. Weather radar imagery showed features consistent with convection and precipitation behind the cold front's leading edge, which was depicted as a

[18] See section 1.8.2 for additional information about activating the go-around mode in a Boeing 767 simulator.

"fine line."[19] At 1238:31, which was the time of the go-around mode activation on the accident flight, the airplane's position coincided with that of the fine line (see figure 8).



Note: The magenta line shows the accident airplane's ground track, and its position at 1238:31 is indicated by a white circle.

Figure 8. Weather radar imagery showing locations of features consistent with convection and a fine line relative to the accident airplane's ground track.

Satellite imagery identified cloudy conditions across the region and over the accident location. When considered with data from an atmospheric model, infrared cloud-top temperatures along the final portion of the accident flight's path corresponded to cloud top heights varying between about 19,500 and 27,300 ft. Regional surface-based measurements of cloud ceilings following the cold front's passage were generally between 2,000 and 3,000 ft above ground level. A video taken by a ground witness near Trinity Bay about 5 minutes after the accident showed a shelf cloud (a type of low-level cloud that forms along a gust front or fine line) passing over the bay near the accident location.

The flight crew of a transport-category airplane that was about 1 mile east of the accident site and at an altitude of about 8,250 ft msl about 8 minutes after the accident reported instrument meteorological conditions (IMC) and "moderate chop" to ATC.

[19] A fine line is a feature sometimes seen in weather radar imagery that most often depicts the leading edge of a frontal boundary, such as a cold front. A fine line presents in the imagery as a long, narrow band of relatively light reflectivity that is not associated with precipitation but rather (in part) insects, birds, and aerosols that have collected along the frontal boundary.

1.5 Flight Recorders

The airplane was equipped with a Honeywell 6022 CVR and a Honeywell 4700 FDR. The CVR was designed to record at least 2 hours of digital audio, and the FDR was capable of recording at least 25 hours of digital flight data. The accident airplane's FDR was required to record a minimum of 34 parameters under grandfathered rules that applied to aircraft with an airworthiness certificate dated before August 18, 2000. (Aircraft with airworthiness certificates after that date and before August 19, 2002, are required to record a minimum of 57 parameters. Aircraft with airworthiness certificates after August 19, 2002, are required to record a minimum of 88 parameters.)

Searches for the CVR and FDR at the accident site detected no acoustic locator beacon signals.[20] The memory modules from both recorders were found during wreckage recovery operations and examined at the NTSB's Vehicle Recorder Division laboratory in Washington, DC.

The CVR's crash-survivable memory unit was found separated from the recorder chassis, and the acoustic locator beacon was neither present on the unit nor ever located. Removal of the internal memory board revealed no structural damage, but water was present under its silicon-like protective coating. Two hours of fair- and poor-quality audio was downloaded, which included recordings from multiple channels that captured audio from three audio panel sources (hot microphones for the captain, FO, and jumpseat) and the cockpit area microphone.[21] Audio quality for the hot microphones was adversely affected by very high frequency radio transmissions that occurred simultaneously with crew conversations, and audio quality for the cockpit area microphone was degraded near the end of the recording.

The FDR's crash-survivable memory unit was found separated from the recorder chassis, and the acoustic locator beacon was neither present on the unit nor ever located. The internal memory module's protective coating had not been breached, and no corrosion or other damage was present on the memory board. The data were downloaded using NTSB hardware, and the recording contained about 54 hours of data.

1.6 Wreckage and Impact Information

1.6.1 General

The airplane crashed into a shallow, muddy marsh area of Trinity Bay, about 41 miles east-southeast of IAH. The wreckage was highly fragmented and dispersed from the initial impact point over a main debris field that covered about 12.3 acres (see figure 9).

[20] Testing with an exemplar acoustic locator beacon found that the signal would not propagate in the shallow water debris field or if the beacon were buried in any amount of mud.

[21] Most crew conversations were unintelligible in the fair-quality audio, but specialized processes were used for the poor-quality audio to make some crew conversations intelligible. See appendix D for the CVR transcript and more information about audio quality ratings.

Figure 9. Wreckage scattered in a marshy area of Trinity Bay.

Most pieces were immersed in or submerged beneath water up to 3 ft deep and buried beneath up to 10 ft of soft mud, while lightweight cargo and composite airplane structure were found floating in the bay or along the shore up to 20 miles south of the initial impact point. Continuous wreckage recovery efforts lasted for almost 7 weeks and included the use of equipment specialized for shallow water operations.

More than 90% of the wreckage was recovered and relocated to a warehouse for examination. The largest pieces of airplane structure were from the upper part of the airplane; structures from the lower third of the fuselage and lower portion of the horizontal stabilizer were fragmented into smaller pieces. Wreckage pieces were examined and sorted, and identified pieces were cataloged in a database and laid out for examination on a two-dimensional reconstruction grid (see figure 10).[22]

[22] See section 1.10.2 for more information about the wreckage recovery and documentation.

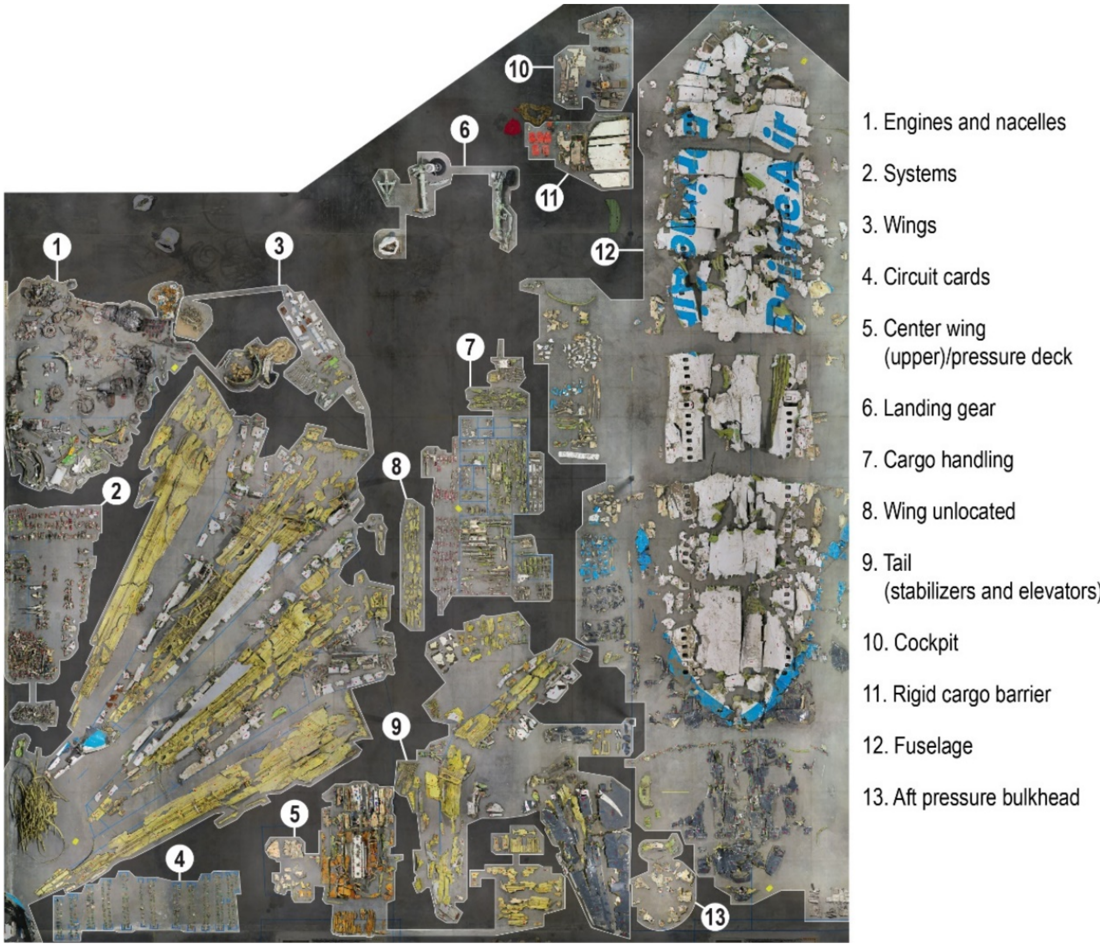


Figure 10. Wreckage reconstruction.

1.6.2 Examinations of Structures, Engines, and Systems

Examination of the airplane structures revealed no evidence of fire, preexisting cracking, or preexisting corrosion, but corrosion associated with the wreckage's exposure to water and mud was noted. All examined fracture surfaces showed features consistent with overstress separation. Most of the rigid cargo barrier (installed in the forward end of the fuselage) and pieces of the aft pressure bulkhead were recovered, and examination revealed no impact marks other than damage consistent with the airplane's crash into the marsh. The cargo locks showed varying levels of damage, consistent with the airplane's impact.

Both engines were highly fragmented, and examination of the recovered components found similar damage to each engine. The extensive damage to the forward half of both engines was consistent with a high-speed collision into the marsh. All of the booster and high-pressure compressor blades in both engines were either broken or bent opposite the direction of rotation. The left and right engines' combustor domes and low-pressure turbine blade airfoils showed no evidence of metal spray material.

FDR data for the entire flight showed that the recorded parameters for each engine were evenly matched (between the two engines) and that the engines responded appropriately to changes in thrust lever position.

The recovered systems components that received detailed examination included the power control assemblies for the elevators, the control stand thrust lever assembly (which included all six microswitch contacts from the go-around switches), and elevator autopilot actuator. All exhibited impact damage, and none were in a condition that allowed for functional testing. Continuity checks were completed using a digital multimeter for each of the microswitch contacts from the go-around switches. No evidence of preimpact failures with any of these components was found.

The FDR data for thrust lever position and discrete parameters for the autopilot and autothrottle were consistent with the selected system settings and other data for the flight. FDR data for EFI switch position was sampled once every 4 seconds and showed both the left and right EFI switches in the "normal" position for the duration of the flight. FDR data for airspeed, which were provided by the left air data computer, were consistent with other data for the flight.

1.7 Medical and Pathological Information

Neither the captain nor the FO reported any use of prescription or nonprescription medication or any health problems on their most recent airman medical applications.

No suitable postmortem specimens from the captain were available for toxicological testing. Results of testing performed on a muscle tissue specimen from the FO were negative for ethanol and a variety of other drugs.[23]

1.8 Tests and Research

1.8.1 Airplane Performance Study

The NTSB's airplane performance study used FDR data, automatic dependent surveillance-broadcast data, and CVR information to evaluate various airplane parameters recorded during the flight.[24] (Basic airplane systems information is included in this section for context.)

Before the go-around mode was activated, the airplane was descending normally at a reduced thrust setting (thrust levers were about 32° to 33°) with an airplane pitch attitude of about 1° nose down and operated with the autopilot and autothrottle engaged. The airplane's automated flight control system could perform climb, cruise, descent, and approach functions as selected by

[23] Ethanol is the type of alcohol found in beer, wine, and liquor.

[24] The FDR recorded (among other parameters) altitude, airspeed, pitch, bank, heading, normalized angle of attack, load factors (in g), and deflection angles for the left and right elevators.

the flight crew using the mode control panel (MCP), FMC, and thrust mode selector. The FDR data indicated that the crew had the assigned altitude of 3,000 ft msl selected using the MCP.

FDR data showed that airplane vertical load factor variations began about 1238:25, with a peak vertical acceleration of 1.26 gravitational acceleration (g); as described in section 1.4, the flight was in the immediate vicinity of the leading edge of a cold front at the time. FDR data at 1238:31 showed that the airplane's automated flight system status for the go-around mode changed to "activated," and the CVR recorded a "click" at this time.[25]

In the accident airplane's configuration with autopilot and autothrottle engaged, the autopilot/flight director system (AFDS) and autothrottle would be expected to respond by controlling airplane pitch, roll, and thrust to maintain ground track, hold the existing airspeed, and establish a climb rate of at least 2,000 ft per minute. During the next 6 seconds, automated flight commands advanced the thrust levers to about 80° to 82°, resulting in increased thrust and longitudinal acceleration, and moved the control column and elevators to command nose-up pitch; during this time, the airplane's pitch increased to about 4° nose up.

About 1238:36, the speedbrake lever was moved from the extended position to the armed position, which retracted the speedbrakes. Recorded airplane parameters at this time, including those for air/ground sensing and flap setting criteria, did not meet the conditions for automatic speedbrake retraction.

Between about 1238:38 to 1238:56, the airplane pitched nose down and continued to accelerate, reaching a peak longitudinal acceleration of 0.27 g at 1238:42. During this time, the position of the left elevator control column (the only side for which the FDR recorded position data) matched the position of the elevators, which was consistent with the elevators responding to manual inputs from a crewmember on an elevator control column.[26] Such a manual override of the autopilot would require control column inputs in excess of 25 lbs. The airplane's nose-down pitch during this time progressed rapidly to about 49° nose down, and the airplane entered a steep descent. At 1238:40, the CVR recorded a beeping sound consistent with the "owl" beeper; the FO then said, "oh" at 1238:44 and "whoa" at 1238:45.[27]

Between 1238:46 and 1238:56, the right elevator was in a more airplane nose-down position than the left elevator, which would be consistent with the captain and the FO each applying differing manual inputs on their respective control columns.[28] At 1238:48 and 1238:51,

[25] A sound spectrum study determined that the click was similar to the sound made during the activation of an exemplar go-around switch but could not conclusively determine its source.

[26] The airplane's elevator system was designed such that, during normal operations, the left and right elevator surfaces typically moved together with matched deflections in response to commands from the automated flight control system or from manual input on the left or right control column. An exception is described later in this section.

[27] The sound was detected again at 1238:58. According to Atlas' flight crew operating manual (FCOM), the owl beeper, which consists of a tone that sounds four times in 1 second, is used for "all system alert caution messages." A sound spectrum study could not determine if the owl beeper sound lasted until the end of the recording.

[28] The elevator system was equipped with override mechanisms that could enable each control column to be commanded independently. The design of the override mechanisms was such that, in the event that differing manual inputs were applied to the left and right control columns, each control column would control only the elevator surfaces on its respective side. A control column force of about 70 lbs (applied to either the left or right control column) is required for the left and right elevator surfaces to move independently from each other.

the FO stated that the airplane was stalling. Review of the airplane's recorded vane angle of attack (AOA), which was below -15°, and airspeed, which was above 250 knots (kts), determined that the airplane's wing stall AOA was not exceeded, and the airplane was not at or near a wing-stalled condition. Also, the FDR's recorded parameter for the stick shaker did not record the stick shaker as being active at any point in the flight.

Beginning about 1238:45, the thrust levers were reduced to 33° within 1 second then increased to about 80° to 85° within 2 seconds. These rates of thrust lever movement were faster than the autothrottle system could command.[29] At 1238:56, the captain asked, "what's goin' on?" At the time, the airplane was descending through an altitude of about 3,000 ft msl, and both elevators began to move concurrently toward an airplane nose-up position.[30] About 2 seconds later, both elevators attained the full airplane nose-up position and remained there until the end of the FDR recording. During this time (beginning at 1238:56), a series of beeps consistent with the "siren" sounded, and the FDR recorded an overspeed.[31]

Just before the FDR recording ended at 1239:03, the airplane's pitch was about 20° nose down, its airspeed was in excess of 400 kts, and its load factor was more than 4 g.

The NTSB's performance study used the longitudinal equations of motion (inputs for which included the airplane's actual pitch angles, directional acceleration in the airplane body axes, directional and angular velocity in the airplane body axes, and acceleration due to gravity) to conceptualize general changes in the gravito-inertial force (GIF) vector that would affect the pilots as the airplane's pitch angle, acceleration, and velocity changed during the flight. Generally, based on these equations, following the activation of the go-around mode, the GIF vector would have increased and moved aft as the airplane accelerated and pitched up. Increased acceleration of the airplane during its subsequent dive would exacerbate the increase and aftward movement of the GIF vector.[32]

1.8.2 Boeing 767 Simulator Scenario Observations

Investigators performed a series of scenarios in a Boeing 767 full-flight simulator to document various indications, alerts, and airplane responses related to operation of the autopilot, autothrottle, go-around switches, speedbrake handle, and EFI switch. The scenarios were flown by

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[29] Manual inputs on the thrust levers could override the autothrottle system but would not disconnect it. According to Boeing, the autothrottle system's maximum rate of thrust lever movement was 10.5° per second.

[30] During this time, the position of the left elevator control column matched the position of the elevators, which was consistent with the elevators responding to manual control inputs.

[31] According to Atlas' FCOM, the siren is used to annunciate "cabin altitude, configuration, autopilot disconnect, and overspeed warning alerts." A sound spectrum study determined that the sound likely began at 1238:56 and continued until at least 1238:59, but the study could not determine if it continued until the end of the recording.

[32] The GIF vector is the mathematical sum of the vectors represented by acceleration of gravity and the acceleration associated with translational motions (such as airplane acceleration). When an airplane accelerates forward, the GIF vector increases in magnitude and is displaced aft (Previc and Ercoline 2004, 28). Otoliths, which are tiny organs of the inner ear that sense linear acceleration, cannot distinguish between these two types of acceleration (gravity and translational motion) and can only sense the combination. Calculating the changes in the GIF vector throughout the final 32 seconds of the flight provided a mathematical basis to understand the forces affecting the pilots and to support analysis related to somatogravic illusion, which is discussed in section 2.3.1.1.

a PF in the right seat to enable investigators to observe how a pilot seated on that side of the airplane interacted with the various airplane controls and displays.

In one scenario, the PF was expediting a descent to 3,000 ft msl (with 3,000 ft msl set on the MCP) with the speedbrakes extended and the autopilot and the autothrottle engaged. At 6,400 ft msl, the PF pushed one of the go-around switches. The investigators observed that the airplane responded by climbing and the speedbrakes did not automatically retract.

Concurrent with go-around mode activation, the flight mode annunciator at the top of each ADI display annunciated “GA/GA/GA/CMD” in green (with a temporary box around each “GA”) to indicate, respectively, that the go-around mode was active for autothrottle, pitch, and roll and that the autopilot function of the AFDS was engaged (see figure 11).[33]

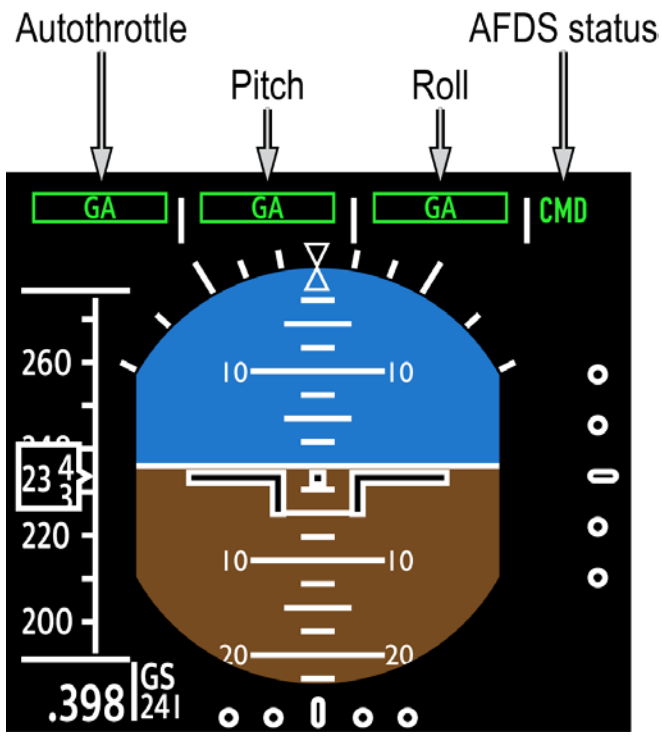

Figure 11. Exemplar ADI showing go-around mode annunciations at the top.

According to Atlas’ flight crew operating manual (FCOM), when using the speedbrakes during flight, “the PF should keep a hand on the speedbrake lever…This helps prevent leaving the speedbrake extended when no longer required.” One Atlas pilot interviewed said that, in his

[33] A green “GA” would also illuminate on the engine indicating and crew-alerting system display to annunciate that the go-around mode thrust limit was active. In most flight regimes, including those in use during the accident flight’s approach to IAH, the autopilot controlled only the ailerons and elevators. Based on FDR data for the accident flight, after the flight was cleared for the expedited descent to 3,000 ft msl, a crewmember set 3,000 ft on the MCP and engaged the “flight level change” mode for the autothrottle and autopilot to automatically descend the airplane to and level off at 3,000 ft msl. Consistent with these selections, at the point in the flight just before the go-around mode was activated, the flight mode annunciator at the top of each ADI display showed “THR HLD/SPD/HDG SEL/CMD” in green to indicate that the thrust hold was active for the autothrottle, the speed hold was controlling pitch, the heading select mode was controlling roll, and the autopilot function of the AFDS was engaged.

experience, the “overwhelming majority [of pilots] if not almost everybody” followed this procedure.

Investigators performing the simulator scenarios had the pilot hold the speedbrake lever using a variety of different hand grip and arm positions. The investigators observed that, when the right-seat PF kept his left hand on the speedbrake lever during the descent (consistent with Atlas’ procedures), the PF’s left hand and wrist could be under the thrust levers and close to the left go-around switch. (The distance between the hand/wrist and the go-around switch varied with different hand grip and arm positions.) The scenarios showed that, if a PF were wearing a watch on the left wrist (as photographs showed the accident FO had done at times), this could result in decreased clearance beneath the go-around switch (see figure 12).

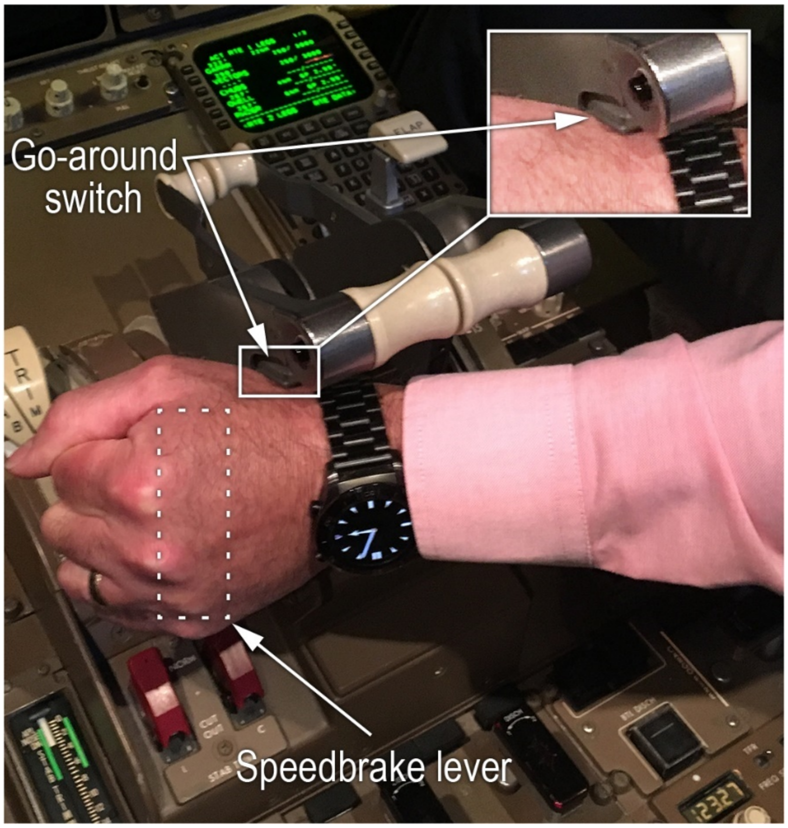

Figure 12. Position of left hand and wrist for exemplar PF in right seat of the simulator holding the speedbrake lever.

Investigators also observed that cycling the EFI switch (to reset the respective SG) took less than 4 seconds to accomplish, did not change the ADI’s presentation of the airspeed data, and did not affect the information displayed by the two conventional Mach/airspeed indicators.

1.8.3 Events Involving Inadvertent Go-Around Mode Activation

In response to NTSB requests for data about any reported events involving inadvertent activation of the go-around mode on Boeing 767-series airplanes, The Boeing Company, Atlas, one other domestic airline (among several contacted), and the National Aeronautics and Space Administration's (NASA) Aviation Safety Reporting System (ASRS) identified no such reports in their respective databases.[34] The ASRS database contained 11 reported events of inadvertent go-around activation that occurred between 1990 and 2017 involving other airplane models, including Boeing 737-, 747-, and 777-series; Airbus A320; Bombardier CL-600; and Embraer EMB170 airplanes.[35]

A review of these ASRS reports revealed that each flight crew was able to correct the situation, but some experienced undesirable results, such as altitude deviations, a missed crossing restriction, and a flap overspeed. One event, which involved a flight crew on a Boeing 747, progressed to stick shaker activation before they regained situational awareness and corrected the condition.

The NTSB is aware of two 1994 accidents and a 1989 incident that involved transport-category airplane models other than the Boeing 767 and included inadvertent activation of the go-around mode in the sequence of events. The investigations of these three events, which occurred in other countries, were led by the respective countries of occurrence (see section 1.10.1 for more information).

1.8.4 Terrain Awareness and Warning System Simulation

The airplane was equipped with a Honeywell enhanced ground proximity warning system, which is a terrain awareness and warning system (TAWS) designed to reduce the risk of controlled flight into terrain by providing flight crews with alerts and warnings about potential terrain conflicts. The unit was not located in the wreckage, and FDR data showed that all parameters related to TAWS alerts remained "off" for the entire accident sequence.

A simulation of TAWS functions performed by the manufacturer using data from the accident flight found that the change in radio altitude values near the end of the FDR recording was considered excessive by the system, which flagged it for internal reasonableness. The system's logic flag caused the simulation to disregard the radio altitude data for 3 seconds. The simulation found that, due to this logic flag and another associated with the rapidity of the accident flight's descent, the FDR recording ended before a TAWS alert would have been issued.

[34] Atlas' internal review included its aviation safety reporting program reports, flight crew reports, and flight data monitoring program data.

[35] There were no reports of any event involving a Boeing 757-series airplane, which shares a similar go-around switch design to Boeing 767-series airplanes.

1.9 Organizational and Management Information

At the time of the accident, Atlas held an air carrier certificate issued in February 1993 and was authorized to conduct flag, domestic, and supplemental operations under Part 121.[36] Its corporate headquarters was in Purchase, New York. The company had 2,922 total employees, which included 1,755 pilots at various bases around the country. Atlas' fleet included 33 Boeing 747-400, 4 Boeing 747-8F, 10 Boeing 767-200, and 26 Boeing 767-300 airplanes.

Atlas had a formal safety management system (SMS), which was defined in its safety and regulatory compliance manual, and its safety structure included an aviation safety reporting program (ASAP) and flight data monitoring (FDM) program.[37] The company used FDM program data to identify aggregate patterns for safety issues such as unstable approaches, hard landings, flap overspeeds, and other events in which predetermined limits for certain airplane parameters were exceeded. Atlas used its SMS, ASAP, and FDM programs to identify safety issues and develop corrective actions such as flight crew training modifications, revised operating procedures, or equipment redesign.

The FAA certificate management team that provided oversight of Atlas was part of the Dallas–Fort Worth, Texas, certificate management office. The three principal inspectors were located within the FAA's Cincinnati, Ohio, flight standards district office. At the time of the accident, the FAA's oversight of Atlas' certificate was performed by a principal operations inspector, a Boeing 747 aircrew program manager and assistant aircrew program manager, a Boeing 767 aircrew program manager and assistant aircrew program manager, and an ASAP manager, among others. FAA personnel used the Safety Assurance System and the Flight Standards Information Management System for their oversight tasks.

The principal operations inspector said he attended an Atlas check pilot group meeting in 2016 in which the group discussed near-future concerns for the company and the industry about incoming pilots who lacked experience in larger airplanes, needed additional training following unsatisfactory checkrides, or needed additional operating experience. The inspector was unaware of any issues at Atlas related to any pilots not meeting FAA standards, and he had no definitive data correlating safety incidents to low experience or lack of proficiency.

[36] Atlas Air Worldwide Holdings, a holding company, included the certificates for Atlas, Polar Air Cargo, and Southern Air. At the time of the accident, Atlas Air Worldwide Holdings was in the process of integrating Southern Air into Atlas, and each of the three certificates had a variety of separate and overlapping functions. The Atlas and Polar Air Cargo certificates were operated independently by separate management but shared a single crew force since March 2012.

[37] Atlas shared a single ASAP with Polar Air Cargo. According to FAA Advisory Circular 120-66C, "Aviation Safety Action Program," the objective of an ASAP is to encourage an operator's employees to voluntarily report safety information that may be critical to identifying potential precursors to accidents and to resolve safety issues through corrective action rather than punishment or discipline. An ASAP provides for the collection, analysis, and retention of safety data, which is used to develop corrective actions to prevent a recurrence of the same type of event (FAA 2020b, 1). To support the FDM program, Atlas equipped fleet airplanes with quick access recorders.

1.9.1 Flight Crew Procedures

According to Atlas' flight operations manual (FOM), the captain has full responsibility and is the final authority for the safe operation of the airplane, whether acting as the PF or the PM.

1.9.1.1 Respective Roles of Pilot Flying and Pilot Monitoring

Per the FOM, the PF's primary task is to fly and navigate the airplane, which includes manipulating the flight controls either directly or through the autoflight systems. The PF is responsible for planning the flight, ensuring a shared mental model among all crewmembers, and executing the plan.

The PM is responsible for observing and commenting on the flight's progress; the PM's primary task is to "quality check" the flight's operation by ensuring the plan the PF shared is in accordance with the standards and briefing. According to the FOM, "recognizing the inevitability of human error on the flight deck, the PM is expected to actively verify that the flight is proceeding according to the plan and alert the PF if the flight deviates from the assumptions of that plan." The PM also performs supporting roles such as running checklists and handling radio communications.

Atlas' FOM stated that, in the event of an emergency:

> The crewmember that first recognized the emergency should announce it in a firm, clear voice. …When the PF is informed or detects an impending emergency or abnormal condition, the PF is expected to:
>
> - Fly the airplane.
> - Evaluate the situation.
> - Call for the appropriate checklist.
> - Complete the prescribed procedure.
>
> One pilot must fly the airplane. The captain may elect to fly the airplane…or to have the other pilot fly it. Assuming control of the airplane does not relieve the captain of the responsibility for directing crew action. Ensure positive transfer of airplane control from one pilot to the other. During the execution of abnormal/non-normal and emergency procedures, a crosscheck and verbal confirmation by two flight crew members (dual response) occurs before the actuation of any critical aircraft system controls.

The FOM stated the safe transfer of control from PF to PM should be made with no assumptions. Before transferring control, the PF should advise the PM of all pertinent information related to automation, navigation, and configuration, and the pilot receiving control should acknowledge the information and transfer.

1.9.1.2 Automated Flight System Management

The FOM stated the following, in part, about automation management:

> Proper automation management relates to situational and/or workload requirements. A pilot's mastery of flight modes, FMC, and MCP inputs toward flight path management is a necessary tool to improve safety and balance workload. However, overuse of autoflight systems may lead to a degradation of the pilot's (and in the end the overall crew's) ability to quickly recover from an undesired aircraft state.

The FOM listed "automation rules of thumb" such as, in the event that automation is a problem, the pilot should reduce the level of automation. Atlas' pilot recurrent training module for the AFDS stated, in part, that "if unwanted operation is noticed or when an autopilot failure is annunciated, the autopilot should be disconnected and the airplane flown manually."[38]

1.9.1.3 Stall Recovery

According to Atlas' FCOM, readily identifiable indications of a stall included stick shaker activation (which vibrated the left and right control columns), initial buffet, stall warning annunciations, and rapid decrease of the airspeed below V_{REF} during landing or go-around.

The FCOM stated that, at the first indication of a stall either through stick shaker or buffet, the PF must initiate the recovery by doing the following:

- Hold the control column firmly.
- Disengage the autopilot and autothrottle.
- Smoothly apply nose-down elevator control to reduce the AOA until stick shaker or buffet stops.

The PM was expected to monitor altitude and airspeed, verify that all required actions are completed, and call out any trend toward terrain contact. Additional procedures for the PF to continue and complete the recovery included rolling the airplane to wings level, advancing the thrust levers as needed, retracting the speedbrakes, returning the airplane to the desired flightpath, and reengaging the autopilot and autothrottle, if desired, among other items.

[38] The autopilot could be disengaged by pressing an autopilot disengage switch located on each pilot's control wheel or by pressing the autopilot disengage bar on the MCP. Autopilot disconnection by either means would be indicated by an "AUTOPILOT DISC" message on the engine indicating and crew-alerting system (EICAS) and an "A/P DISC" annunciation. The autothrottle could be disengaged by pressing an autothrottle disengage switch located on each thrust lever or by positioning the autothrottle arm switch on the MCP to the "OFF" position. Autothrottle disconnection by either means would be indicated by an "AUTOTHROT DISC" message on the EICAS and an "A/T DISC" annunciation.

1.9.1.4 Pitch Upset Recovery

Atlas' FCOM for the Boeing 767 defined an upset as an inadvertent aircraft attitude occurring as a result of turbulence, instrument failure, distraction, spatial disorientation, or transition from visual meteorological conditions (VMC) to IMC. Pitch upsets were generally defined as unintentionally exceeding 10° nose-down pitch or 25° nose-up pitch.[39]

The FCOM stated that, in most cases, upsets were mild enough that reestablishing the proper attitude for the desired flight condition and resuming a normal instrument scan will ensure recovery. In all cases, however, successful recoveries were based on a distinct pattern of actions: recognize, confirm, and recover. The FCOM emphasized that top priority should be given to early recognition and rapid correction of attitude excursions, including transitioning to instrument references any time disorientation occurs or outside visual references become unreliable.

During the recognition process, the attitude must be correctly interpreted by crosschecking other sources of information (for example, the other pilot's attitude display or the standby attitude indicator) to determine if an attitude display failure might be the cause. Regardless of how the upset was recognized, the pilot must verify that an upset occurred by comparing control and performance instrument indications before initiating the recovery on the attitude display. Such comparison was meant to prevent aggravating the upset as a result of making control movements based on erroneous instrument indications.

According to Atlas' upset recovery training aid:

> In most cases, effective situational awareness will avoid an upset from developing in the first place. However, it is important that the first actions for recovering from an airplane upset be correct and timely. Exaggerated control inputs through reflex responses must be avoided. It is worth repeating that inappropriate control inputs during one upset recovery can lead to a different upset situation. Troubleshooting the cause of the upset is secondary to initiating the recovery. However, the pilot still must recognize and confirm the situation before a recovery can be initiated. Regaining and then maintaining control of the airplane is paramount. Communicating between crew members will assist in the recovery actions. At the first indication of an unusual occurrence, the pilot should announce what is being observed.

Nose-down upset recovery procedures in the FCOM stated that after the PF recognized and confirmed the developing situation with the PM, the PF was to disconnect the autopilot and autothrottle, roll the airplane to a wings-level attitude, and apply nose-up elevator control and, if needed, trim. Procedures for the PM included calling out attitude, altitude, and airspeed throughout the recovery and verifying all needed actions were completed. Nose-up upset recovery procedures were generally similar but involved applying nose-down elevator control inputs.

[39] Other upset conditions were bank angle greater than 45° or airspeed inappropriate for the conditions.

1.9.2 Pilot Training Program

Atlas' approved training program was described in its FAA-approved flight operations training manual (FOTM), which was the authority for all of Atlas' training program requirements, policies, and supporting information. Atlas used its own instructors and check airmen to conduct pilot training and evaluations, and ground school and simulator training for Boeing 767 pilots was conducted at Atlas' training center in Miami, Florida. According to the FOM, the fleet captain was responsible for flight crew initial and transition training; instructor and check pilot selection, training, and management; administration of the PWP; and training program compliance with regulations, company policies, and labor agreements.

Atlas maintained current records for all crewmembers showing compliance with the proficiency and qualification requirements specified under Part 121. Any Atlas crewmember who failed a check was considered unqualified to fly until the deficiency was remediated and the check passed. Atlas had a remedial training protocol, and the fleet captain had wide discretion to provide specific training tailored to help the crewmember return to a satisfactory level of performance. Remedial training could include a records review, additional training, and/or counseling.

Atlas also had a training review board, established in December 2015, to represent the company (when working with the pilots' union) in making decisions on whether to remove a pilot from the training program or provide additional training.[40] The training review board would become involved after a pilot's third unsuccessful training event in any training program.

1.9.2.1 Proficiency Watch Program

Atlas' PWP was established to comply with the 14 *CFR* 121.415 requirements for crewmember training programs, including processes for tracking performance deficiencies and remedial training. As specified in Atlas' FOTM, the PWP was intended as a tool to monitor and improve the performance of crewmembers who failed to satisfactorily complete a training or qualification event, exhibited performance that did not meet company standards, or demonstrated a repetitive need for additional training. According to Atlas' fleet captain, the PWP was modified in April 2016 to exclude a single failure as a triggering event for placing a pilot into the PWP.

Pilots placed into the PWP would be monitored for at least 6 months, receive a recurrent flight training session after 3 months, and receive a proficiency check and line check after 6 months (provided the requisite operating experience requirements were completed).[41] Atlas would release a pilot from the PWP after successful completion of all program requirements.

[40] Atlas' pilots were covered under a collective bargaining agreement between Atlas and the International Brotherhood of Teamsters, Airline Division since December 22, 2008.

[41] Crewmember flight scheduling and other factors could affect how long a pilot would take to complete the PWP requirements.

1.9.2.2 Remedial Training Decisions for Accident Flight Crew

As described in section 1.2.1.1, on November 11, 2015, Atlas placed the accident captain (as an FO) in the PWP, citing his "repetitive need for additional training" before he was recommended for the Boeing 767 type-rating checkride. He was removed from the PWP on February 22, 2017, after having "successfully completed the requirements" of the program. The accident captain exhibited no further deficiencies requiring remedial training during any subsequent recurrent training, upgrade training, or proficiency checks at Atlas.

As described in section 1.2.2.1, during the accident FO's initial training at Atlas between July and September 2017, he was assigned (and successfully completed) remedial training before being recommended for the Boeing 767 type-rating oral examination and Boeing 767 full-flight simulator training. He also received remedial training after failing the practical Boeing 767 type-rating examination.

During a postaccident interview, the fleet captain said the FO's difficulties during initial training did not meet the criteria for referral to the training review board. The fleet captain said that, when considering whether to place the FO in the PWP, he decided to monitor the FO's operating experience.[42] The fleet captain believed that factors beyond the FO's control may have adversely affected the FO's training performance, including the hurricane-induced interruption in his training and some family issues the FO was experiencing. The fleet captain also believed that the FO may have been nervous during his type-rating checkride because an FAA inspector was present to observe the check airman.

Between October 26 and November 22, 2017, the FO received 53 hours of initial operating experience on the Boeing 767, all of which was completed with an Atlas check airman.[43] The FO had no difficulties with his subsequent recurrent training and proficiency checks at Atlas.

1.9.3 Pilot Hiring Process

1.9.3.1 General

Atlas' minimum pilot qualifications for employment included an ATP certificate, current first-class medical certificate, and flight experience of at least 1,500 total hours, to include at least 500 hours turbine time and at least 1,000 hours in airplanes or 500 hours with a Part 121 carrier.

[42] As mentioned in section 1.9.2.1, the PWP was modified in April 2016 to exclude a single failure as a triggering event for placing a pilot into the program, making placement in the program more subjective than when the accident captain had been placed in it.

[43] Crewmember flight scheduling and other factors could affect how long a pilot would need to complete the initial operating experience requirements (regulations required a minimum of 25 hours). For example, the FO accumulated about 36 hours of initial operating experience (which included two landings) during his first five trips, which were lengthy, overseas flights. The remainder of his initial operating experience included seven shorter flights and an additional six landings.

In 2018, Atlas and Southern Air (whose certificate Atlas Air Worldwide Holdings was integrating into Atlas) had hired 336 pilots, combined, with an average total flight time of 6,550 hours.[44]

According to Atlas' human resources (HR) director, the company received about 1,200 to 1,400 pilot applications each year. The HR director said that a pilot applicant with 3,000 to 6,000 flight hours, a turbojet type-rating, 3 to 5 years of regional airline experience, and a good work and training history would be considered a competitive applicant.

Atlas' procedures for considering pilot applicants included an initial review for minimum requirements, resume review, and initial telephone screening with a recruiter before an interview would be scheduled. Atlas' HR director and the senior director of flight procedures, training, and standards (director of training) said the application process relied on the applicants' honesty in disclosing information. The HR director said the process included crosschecking to ensure that information provided during interviews, on the application, and in the background check all agreed but noted that "it's hard to catch someone who's deliberately trying to deceive you."

Interviews were conducted by the personnel panel (made up of HR personnel and a company flight operations management pilot, such as director of training or chief pilot) and the technical panel (typically consisting of a retired captain). The personnel and technical panels would separately score applicants on a rating sheet, then both panels would meet and discuss the applicant.[45] Applicants were rated as "highly recommended," "recommended," or "do not recommend for employment." Atlas' HR director and the director of training, who jointly made all final decisions, controlled the hiring process.

When the accident captain applied for a job with Atlas, he listed his three previous employers, which represented a continuous employment history back to March 2002. Atlas' director of training recalled that he had interviewed the accident captain in 2015 and had no areas of concern.

When the accident FO applied for a job at Atlas, he did not disclose that he had worked briefly for and resigned from both CommutAir (in 2011) and Air Wisconsin Airlines (in 2012). The FO stated on his Atlas employment application that gaps in his employment history were times when he was furloughed, working as a freelance real estate agent, or attending college.[46] Atlas' director of training said he would have liked to have known about the FO's work history at CommutAir and Air Wisconsin Airlines during hiring so he could have further evaluated trends in the FO's training. He considered an applicant's failure to disclose employer information as deceptive and possibly grounds for termination if discovered after hire.

[44] In 2017, 2016, 2015, and 2014, respectively, Atlas and Southern Air, combined, had hired 316 pilots with an average flight time of 6,643 hours; 323 pilots with an average flight time of 6,807 hours; 341 pilots with an average flight time of 6,498 hours; and 92 pilots with an average flight time of 7,303 hours.

[45] The personnel panel rated candidates on several factors, including overall organizational fit, employment history, CRM proficiency, personality, assertiveness, training history, and experience level. The technical panel performed a 20- to 30-minute review of the applicant's technical skills, general knowledge level, and trainability.

[46] A record showed the FO received a bachelor's degree from Florida International University on April 30, 2011. The resume he provided to Atlas indicated that he also received a bachelor's degree from Florida Memorial College but did not specify the date of that degree or his enrollment dates at either school.

On the FO's application for employment at Atlas, he answered "yes" when asked if he had "ever failed an initial, upgrade, transition, or recurrent proficiency check" and stated, "when I was doing my ATP checkride, I had to redo one nonprecision approach." As described in section 1.2.2.2, this failure occurred in May 2014 while the FO was employed at Trans States Airlines. Atlas' HR director recalled that the FO discussed this failure during his interview, and Atlas had received a record (from Trans States Airlines) of this failure and the FO's subsequent unsatisfactory line checks as part of its background check on the FO (see section 1.9.3.2).

On his Atlas application, the FO did not list his unsuccessful attempt to upgrade to captain on the Embraer ERJ175 while employed at Mesa Airlines. The Mesa training records provided to Atlas as part of the FO's background check contained nine line items dated May 12, 2017 (including "Line Operational Evaluation," "Maneuvers Validation," and "Line Check"). Each of these items stated, "PER EMAIL RECEVIED ON 09MAY17, HE IS RETURNING TO FO [*capitalization in original*]," indicating that the FO did not successfully upgrade to captain.

Neither the HR director nor the director of training was aware that Mesa's training records referenced the unsuccessful captain upgrade attempt, and both said that such a training event should have been "red flagged" during the background check process (see section 1.9.3.2). When asked how Atlas classified an unsuccessful attempt to upgrade to captain, the HR director said, "if I had seen that, we probably would've asked him about it, and then he would've explained what it was." Atlas' director of training said he would have liked to have had that information for follow-up questioning with the FO.

Hiring records for the FO showed that he was rated "highly recommended" by both panels. His rating sheet included a disclosure from the FO about a failure in 2014 for his ATP certificate and a hand-written comment that stated, "really nice," and that no Level D simulator evaluation of the FO was required for the interview process.

1.9.3.2 PRIA Records Review

The Pilot Records Improvement Act (PRIA) of 1996 specified that a hiring operator could not place a pilot into service until it obtained and reviewed specified background and other safety-related records on that pilot from the last 5 years. The PRIA requirement for obtaining records applied to Part 119 certificate holders (air carriers and commercial operators with authority to conduct operations under Part 121, Part 125, and/or Part 135), governmental entities conducting public aircraft operations, air tour operators, and fractional ownership programs. The information required by the PRIA included records from the FAA, the National Driver Register (NDR), and previous employers. These records included information that previous employers were required to provide about the pilot's training, experience, qualifications, safety background, and performance as a pilot.

Under the PRIA, pilot applicants were required to provide hiring operators with information on all previous employers for which the applicant was employed as a pilot within the preceding 5 years. Atlas used a third-party designated agent (DA) to conduct PRIA background checks of pilot applicants. According to FAA guidance outlined in Advisory Circular (AC) 120-68H, "Pilot Records Improvement Act and Pilot Records Database," an operator may use a DA to obtain pilot records, but the operator is ultimately responsible for evaluating those records (FAA 2017, 3.1).

According to Atlas' HR director, the DA would review the applicants' records and notify her of any significant events like training failures, which she considered a "red flag," that HR staff would bring to the director of training's attention. When asked if she believed that the DA should identify and "red flag" an event such as a failure to upgrade to captain, the HR director said, "Yes. Emphatically, yes." She said the HR personnel were not reliant on the DA and that either she or a member of her staff would also review the background records and notify the director of training if they saw anything of concern. Atlas' director of training said that both the DA and Atlas' HR department would flag substantial issues in the training records for his attention.

PRIA background records for the captain were obtained by a DA on September 22, 2015, and included information from the FAA, NDR, and the captain's three previous employers. According to the HR director, the captain's background records did not disclose any issues of concern.

PRIA background records for the FO were obtained by a DA on August 11, 2017, and included information from the NDR, FAA, and the four employers that the FO disclosed to Atlas: Mesa Airlines, Trans States Airlines, Charter Air Transport, and Air Turks and Caicos.

As described in the previous section, the HR director and the director of training were unaware that the FO's background information provided by Mesa Airlines included a record of his unsuccessful May 2017 captain upgrade attempt. The HR director said she never received a "red flag" from the DA about this event. She noted that, in reviewing the records after the accident, the unsuccessful upgrade attempt was presented in such a way that "it did not present as a red flag." She also said that, in hindsight, she could see how the record's comment "returning to FO" referred to captain upgrade training. In reviewing the record after the accident, the director of training said the information provided in the record was vague and should have been identified for additional follow-up.

1.10 Additional Information

1.10.1 FAA Initiatives to Reduce Flight Crew Mode Confusion Errors

Mode awareness is a pilot's ability to track and anticipate the behavior of an automated system (Sarter and Woods 1995). When mode awareness breaks down, pilot expectations of system performance are disrupted, and pilots may make mode confusion errors, including actions or omissions that are not appropriate for the currently active modes, and experience automation surprises. Mode confusion errors and automation surprises are long-recognized hazards in aviation.

The NTSB is aware of three accidents or incidents in which the sequence of events included inadvertent activation of the go-around mode: a 1994 accident involving an Airbus A300B4-622R in Nagoya, Japan; a 1994 accident involving a McDonnell Douglas DC-9-83 in Kajaani, Finland; and a 1989 incident involving an Airbus A300-B4 in Helsinki, Finland. The investigations were led by the respective countries of occurrence, and each identified multiple crew-related issues and other factors. The FAA referenced two of these events in its 1996 report of a human factors team study that evaluated the interfaces between flight crews and automated flight systems on transport-category airplanes.[47]

The team for this study included representatives from the FAA, NASA, the Joint Aviation Authorities, and academia. The 1996 report for the study cited concern about vulnerabilities in flight crew mode awareness and the impact of these vulnerabilities on flight crew performance and included numerous recommendations intended to reduce flight crew mode confusion errors, among other goals.

The FAA's work continued and, in 2013, a joint working group with industry published a report on its study of the operational use of flightpath management systems. The report concluded that automated systems "have contributed significantly to improvements in safety, operational efficiency, and precise flight path management" but noted that vulnerabilities remain, including flight crew mode confusion errors with autoflight systems (FAA 2013b, 3). The report's recommendations included more practice for pilots in manual flight operations; enhanced training and procedures to improve mode awareness; future designs with less complex, more intuitive modes; and improved feedback to pilots on both mode status and transitions (FAA 2013b, 6-10).

The FAA also issued new certification requirements in 14 *CFR* 25.1302 and published related guidance in AC 25.1302-1, "Installed Systems and Equipment for Use by the Flight Crew," intended to minimize design-related errors and to enable crews to better detect and manage them. Title 14 *CFR* 25.1302 contained provisions that augmented existing design requirements and specified such mandates as ensuring that controls and information displays are usable by the flight crew and allow them to safely accomplish all their tasks. This included, in part, providing the flight crew with controls and information that include appropriate feedback information about the effects of their actions on the airplane; are presented in a clear and unambiguous form; are accessible and usable in a manner consistent with the urgency, frequency and duration of their tasks; and enables the flight crew to detect and correct their own errors (FAA 2013a).

1.10.2 Effective Investigative Techniques

Wreckage recovery, identification, and examination activities for this accident were extensive. Recovery operations spanned 7 weeks and required the use of airboats, barges, an

[47] The FAA report referenced the 1994 fatal accident in which the FO of an Airbus A300B4-622R (operated by China Airlines) inadvertently activated the go-around mode while the airplane was on approach to an airport in Nagoya, Japan. In that accident, the flight crew subsequently applied manual control inputs to continue the approach; by the time they disengaged the autopilot, the airplane was in an abnormal, out-of-trim condition that resulted in a steep, nose-up pitch and climb. The flight crew's recovery efforts were unsuccessful, and the airplane stalled and crashed, killing 264 of the 271 people on board (FAA 1996, AAICJ 1996). The FAA report also referenced the 1989 incident in which the captain of an Airbus A300-B4 (operated by KAR Air) inadvertently activated the go-around mode while the flight was on approach to an airport in Helsinki, Finland. In that incident, the flight crew immediately retrimmed the airplane for a successful recovery (FAA 1996). The third event, which was not referenced in the FAA's report, was the 1994 accident in which the flight crew of a McDonnell Douglas DC-9-83 (operated by Air Liberte Tunisie) inadvertently activated the go-around mode while the flight was at an altitude of 120 ft above ground level on approach to an airport in Kajaani, Finland (AIBF 1996). The crew landed the airplane with increased thrust and excessive speed, resulting in a runway excursion and substantial damage to the airplane.

amphibious crane, and two amphibious excavators. Excavator buckets were fitted with specially developed screens to allow mud and water to drain while retaining any wreckage debris larger than 4 inches. Recovered wreckage and cargo included about 10,000 lbs of small debris.

Investigators developed a scheme to examine each piece of recovered wreckage, assign each conclusively identified piece a unique identifier, and catalogue each identified piece into a database, which included photographs and identifying information. Investigators incorporated these identified pieces into a two-dimensional layout of the airplane on a warehouse floor.

Several techniques for photo-documenting the accident site and reconstruction were used. These included processing high-resolution aerial imagery of the accident site (obtained by a local company using a small unmanned aircraft system [UAS] immediately after the accident) into a georeferenced digital orthomosaic image of the accident site. Also, the NTSB's UAS Team acquired high-resolution aerial imagery of the wreckage reconstruction (using two small UAS inside the warehouse) and processed it using commercially available photogrammetry software to develop a three-dimensional model of the reconstruction (a screen capture from which was used to create figure 10). The Boeing Advanced Photographic Engineering Experience team acquired 66 high-resolution 360° images of the wreckage layout, which were processed into a Virtual Tour of the reconstruction. Collectively, these documentation methods preserved the accident scene and the wreckage reconstruction in a highly accurate, digital format.

1.11 Postaccident Actions

After the accident, Atlas revised its interview process to strengthen its existing procedures. It now includes a telephone screening interview where questions are asked to gauge credibility and consistency in the applicant's answers during the formal interview. Additionally, Atlas added a pilot logbook review to the interview process to obtain a better picture of the applicant's overall career trajectory.

Atlas also added an additional level of review of each candidate's PRIA records by a member of the flight operations team to provide an additional technical perspective to its candidate vetting process. Atlas also revised its pilot selection process with a standard operating procedure dedicated solely to pilot hiring.

2. Analysis

2.1 Introduction

The accident flight's departure from MIA, en route cruise, and initial descent toward IAH were uneventful. As the flight descended toward the airport on a published arrival route, the flight crew requested to deviate course to pass west of an area of precipitation. The controller advised the crew to expedite the descent and assigned the flight a left turn to the west, which the crew acknowledged. Analysis of the available weather information determined that, at the time, the accident flight was likely operating in VMC.

As the flight continued its descent toward the airport, the crew extended the speedbrakes, lowered the slats, and began setting up the FMC for the approach. The FO was the PF, the captain was the PM, and the autopilot and autothrottle were engaged and remained engaged for the remainder of the flight.

FDR data showed that, beginning about 1238:25, the airplane experienced vertical load factor variations with a peak vertical acceleration of 1.26 g. Analysis of the available weather information determined that, at the time, the airplane was beginning to penetrate the leading edge of a cold front, within which associated windshear and IMC (as the flight continued) were likely. Generally, an aircraft load of ±0.26 g (the deviation from 1 g) would correspond with an encounter with turbulence in the lower end of the "light" severity classification (Sharman 2006, 7). During a light turbulence encounter, occupants inside an aircraft "may feel a slight strain against the seatbelts or shoulder straps," and "unsecured objects may be displaced slightly" (FAA 2020a, 7-1-44).

Concurrent with the accident flight's encounter with light turbulence, at 1238:31, the airplane's go-around mode was activated. At the time, the accident flight was about 40 miles from IAH and descending through about 6,300 ft msl toward the target altitude of 3,000 ft msl. This location and phase of flight were inconsistent with any scenario in which a pilot would intentionally select go-around mode, and neither pilot made a go-around callout to indicate intentional activation. Therefore, the NTSB concludes that the activation of the airplane's go-around mode was unintended and unexpected by the pilots and occurred when the flight was encountering light turbulence and likely IMC associated with its penetration of the leading edge of a cold front.

Within seconds of go-around mode activation, manual elevator control inputs overrode the autopilot and eventually forced the airplane into a steep dive from which the crew did not recover. Only 32 seconds elapsed between the go-around mode activation and the airplane's ground impact.

The NTSB notes that, about 2 minutes before the go-around mode was activated, the CVR captured a conversation that suggested the FO had briefly experienced an anomaly with his EFIS display. The FO transferred PF duties to the captain and mentioned the EFI switch, which pilots can use to resolve display faults. Transferring control of the airplane to the other pilot would be consistent with Atlas' procedures for a PF needing to address a non-normal occurrence, such as a display issue. Two seconds after the FO mentioned the EFI switch, he said, "okay, I got it back," presumably referring to his displays, and the captain acknowledged.

Although the FDR data do not show any changes in the EFI switch position during the flight, that parameter was sampled only once every 4 seconds, and simulator observations showed the EFI switch could be cycled (from normal to alternate and back) to clear an issue such as an intermittent display blanking in less than 4 seconds. Addressing a display fault involving a loss of parametric data would require a pilot to set the EFI switch to the alternate position and leave it there. Thus, the NTSB concludes that, whatever EFIS display anomaly the FO experienced was resolved to both crewmembers' satisfaction (by the FO's cycling of the EFI switch) before the events related to the accident sequence occurred.

The following analysis evaluates these safety issues:

- **Inadvertent activation of the go-around mode.** The investigation determined a likely scenario to explain how the go-around mode became activated (section 2.2);

- **Flight crew performance.** The investigation examined the factors that influenced the FO's incorrect response following the unexpected mode change (section 2.3.1) and the captain's delayed awareness of and ineffective response to the situation (section 2.3.2);

- **Atlas' evaluation of the FO.** The FO failed to disclose to Atlas some of the training difficulties he experienced at former employers (2.4.1), and Atlas' records review did not identify the FO's past training failure at one former employer, which may have affected how Atlas evaluated him during the hiring process (2.4.2) and during training (2.4.3);

- **Industry pilot hiring process deficiencies.** Limitations in the background records retrieval process places hiring operators at a disadvantage when trying to obtain a complete training history on a pilot applicant (2.5.1). Also, the circumstances of this accident highlighted a need for improved pilot selection and performance measurement methods (2.5.2);

- **Awareness information for Boeing 767 and 757 pilots.** Although there were no other known events involving inadvertent activation of the go-around mode on a Boeing 767-series airplane, pilots of Boeing 767- and 757-series airplanes (which share a similar go-around switch design) could benefit from understanding the circumstances of this accident (section 2.6.1);

- **Adaptations of automatic ground collision avoidance technology.** The US military has successfully equipped some fighter airplanes with an automatic ground collision avoidance system (auto GCAS) that has prevented the loss of several aircraft and saved lives. Research into adapting such technology for lower-performance, less-maneuverable airplanes could have relevance for civil transport-category airplanes (section 2.6.2); and

- **Cockpit image recorders.** Certain aspects of the circumstances of this accident could be better known with improved information about flight crew actions, which could lead to more and better-targeted safety recommendations for preventing similar accidents (section 2.7).

After completing a comprehensive review of the circumstances that led to this accident, the investigation established that the following factors did not contribute to the cause of the accident:

Flight crew regulatory and company qualifications. The captain and the FO possessed valid and current FAA pilot and medical certificates, were certified in accordance with FAA regulations, and met the currency and qualification requirements specified in Atlas' training program.

ATC services. ATC services provided throughout the accident flight were routine and uneventful. The weather services and instructions for the expedited descent provided by the last air traffic controller to handle the flight were consistent with procedures. The flight turned to its assigned heading and did not encounter any hazardous convective weather or traffic conflicts.

Airplane mechanical condition, maintenance, and weight and balance. Aside from the brief EFIS display anomaly described above, there was no evidence of preimpact anomalies or discrepancies with the airplane's structures, powerplants, or systems components, including the recovered power control assemblies for the elevators, the control stand thrust lever assembly (which contained the microswitches for both go-around switches), and the elevator autopilot actuator. The recovered wreckage showed no evidence of fire, appreciable corrosion, or preexisting cracking. Atlas maintained the airplane in accordance with applicable requirements, and reviews of maintenance records revealed no items of concern. The weight and balance of the airplane were within limits, and examination of the airplane's rigid cargo barrier, aft pressure bulkhead, and cargo locks revealed no evidence of a cargo shift.

Thus, the NTSB concludes that none of the following were factors in this accident: (1) the captain's and the FO's certifications and qualifications; (2) ATC services; (3) the condition and maintenance of airplane structures, powerplants, and systems; and (4) airplane weight and balance.

The captain's and the FO's duty hours and number of flights flown were low during the 72 hours before the accident, but only limited information was available about their sleep and off-duty activities. Both crewmembers had transitioned between working a night shift (on the day before the accident) then a day shift (the accident shift), raising the possibility of fatigue due to circadian disruption and associated sleep restriction. However, without information about their actual sleep obtained, the likelihood that they were experiencing fatigue and the magnitude of any fatigue-related effects on their performance cannot be reliably estimated.

Neither crewmember reported any medications or any significant medical conditions on their most recent airman medical applications. Toxicological testing performed on specimens from the FO revealed no evidence of ethanol or other drugs, but no suitable specimens were available for the captain. Thus, the NTSB concludes that there was insufficient information to determine whether the flight crewmembers were fatigued at the time of the accident, and no available evidence suggested impairment due to any medical condition, alcohol, or other impairing drugs.

2.2 Inadvertent Activation of the Go-Around Mode

Activating the airplane's go-around mode requires a pilot to push one of the go-around switches on the outboard underside of either thrust lever. The characteristics of a "click" sound detected by the CVR, which corresponded with FDR data for the mode change, provided evidence that the go-around mode was activated using one of the go-around switches. Although the available evidence precluded a conclusive determination of which go-around switch was pushed or how, the investigation determined a likely scenario.

Atlas' pilot training and procedures prescribed that, during operations with automated flight control systems engaged and the speedbrakes extended, the PF should keep one hand on the speedbrake lever as a reminder to retract the speedbrakes upon the autopilot's capture of the selected altitude and associated automatic increase in thrust. Thus, the FO (as PF) likely had his hand on the speedbrake lever in accordance with Atlas' guidance and in anticipation of retracting the speedbrakes once the airplane began to level off at its target altitude of 3,000 ft msl.

Simulator observations of pilots performing this scenario showed that, for a PF in the right seat, holding the speedbrake lever can place the left hand and wrist under the thrust levers and close to the left go-around switch such that very little upward arm movement would be needed to make contact with the switch.[48] For the accident flight, the effects inside the airplane during its encounter with light turbulence at the time the go-around mode was activated could be sufficient to move a crewmember's arm this small distance. Therefore, the NTSB concludes that, presuming that the FO was holding the speedbrake lever as expected in accordance with Atlas' procedure, the inadvertent activation of the go-around mode likely resulted from unintended contact between the FO's left wrist or watch and the left go-around switch due to turbulence-induced loads that moved his arm.

2.3 Flight Crew Performance

Before the inadvertent activation of the go-around mode, the airplane was descending to a target altitude of 3,000 ft msl, and the flight crew would have been expecting the airplane's automation to increase thrust and increase pitch slightly from about 1° nose-down to level off once the flight reached that altitude. However, once the go-around mode was inadvertently activated about 6,300 ft msl, the airplane's automation advanced the thrust levers and increased the airplane's pitch to about 4° nose up to initiate a climb. In addition, the flight mode annunciator changed to indicate go-around mode activation by illuminating "GA/GA/GA/CMD."

[48] For a PF in the right seat wearing a watch on the left wrist (as the accident FO was shown to have done), the clearance beneath the go-around switch would be reduced, and the PF may not easily feel or notice inadvertent contact between the watch and the switch. However, it is not known if the FO was wearing a watch during the accident flight.

The unexpected mode change associated with the inadvertent go-around mode activation (and the higher altitude at which it occurred) would have been recognizable to the FO and the captain through an effective instrument scan. Both the flight mode annunciator and the engine indicating and crew-alerting system (EICAS) would have displayed "GA" indications, and the altimeter would have indicated about 6,300 ft msl.

According to Atlas' procedures, the expected crew response to unwanted operation of automated flight systems was to disconnect the automation. However, neither the FO nor the captain ever acknowledged that the airplane had transitioned to go-around mode or disengaged the autopilot or autothrottle. Thus, the NTSB concludes that, despite the presence of the go-around mode indications on the flight mode annunciator and other cues that indicated that the airplane had transitioned to an automated flight path that differed from what the crew had been expecting, neither the FO nor the captain were aware that the airplane's automated flight mode had changed. Research has shown that pilots can miss changes in displayed modes, particularly those that are unexpected (Mumaw et al 2000), and other factors (discussed in the next sections) may have reduced the effectiveness of each crewmember's scan.

2.3.1 First Officer's Incorrect Response Following Unexpected Mode Change

Although the FO did not verbalize awareness that something unexpected had happened until about 13 seconds after go-around mode activation (when he said "oh" and then "whoa" in an elevated voice), manual control inputs that began sooner suggest that the FO (as PF) had sensed changes in the airplane's state and had begun to react without fully assessing the situation.

The manual retraction of the speedbrakes 5 seconds after go-around mode activation was likely performed by the FO (as PF) instinctively once he felt the increased load factor from the airplane leveling off and heard and felt the engine thrust increasing. He had likely been anticipating the need to perform this task when the airplane leveled off.

However, beginning about 1 second later, as the airplane's acceleration and upward pitch began to increase (which would have resulted in the aft movement of the GIF vector sensed by the pilots), manual forward control column inputs were applied, overriding the small, autopilot-driven pitch-up command and resulting in decreasing pitch. Thus, the NTSB concludes that, given that the FO was the PF and had not verbalized any problem to the captain or initiated a positive transfer of airplane control, the manual forward elevator control column inputs that were applied seconds after the inadvertent activation of the go-around mode were likely made by the FO. Further, the captain was communicating with an air traffic controller at the time, consistent with his PM duties.

2.3.1.1 Somatogravic Illusion

The human body uses three integrated systems to determine orientation and movement in space: vestibular (otolith organs in the inner ear that sense position), somatosensory (nerves in the skin, muscles, and joints that sense position based on gravity, feeling, and sound), and visual (eyes, which sense position based on sight) (FAA 2016, 17-6). The vestibular and somatosensory systems alone cannot distinguish between acceleration forces due to gravity and those resulting from maneuvering the airplane.

Thus, when visual cues are limited and an airplane rapidly accelerates or decelerates, a pilot may be susceptible to a somatogravic illusion (FAA 2016, 17-6). Somatogravic illusion is a form of spatial disorientation that results from a false sensation of pitch due to the inability of the otolith organs of the human inner ear to separate the gravitational and sustained linear acceleration components of the GIF vector (Young 2003 and Cheung 2004). Rapid acceleration in an airplane stimulates the otolith organs in the same way as tilting the head backward and may lead a pilot to mistakenly believe that the airplane has transitioned to a nose-up attitude (FAA 2016, 17-7).[49]

The accident airplane was likely flying in IMC when the go-around mode was activated. The timing of the FO's subsequent nose-down control inputs correlated with increases in the airplane's longitudinal acceleration associated with the go-around mode-commanded increase in engine thrust and retraction of the speedbrakes. This relationship suggests that the FO experienced a pitch-up somatogravic illusion at that time.

Somatogravic illusion has long been recognized as a significant hazard that is likely to occur under conditions of sustained linear acceleration when outside visual references are obscured (Buley and Spelina 1970, 553-6). Further, such conditions can degrade a pilot's ability to effectively scan and interpret the information presented on primary flight displays.[50] For a pilot flying in IMC with no external visual horizon, maintaining spatial orientation when presented with conflicting vestibular cues depends upon trusting the airplane's instruments and disregarding the sensory perceptions (FAA 2003, 8). However, for some pilots (particularly those who are not proficient with maintaining airplane control while referencing only instruments), the introduction of misleading vestibular cues can be compelling enough that the pilot may find it difficult to accurately assess or believe reliable sources of information about airplane attitude, such as the airplane's instruments. Thus, the NTSB concludes that the FO likely experienced a pitch-up somatogravic illusion as the airplane accelerated due to the inadvertent activation of the go-around mode, which prompted him to push forward on the elevator control column.

After the FO began pushing forward on the control column and the airplane's pitch dropped below the horizon, its vertical acceleration rapidly decreased. Due to this change and the airplane's continued longitudinal acceleration, the resultant GIF vector sensed by the pilots swung dramatically aft. This likely exacerbated the FO's pitch-up sensation and possibly produced a sensation of tumbling backward, known as the inversion illusion (Cheung 2004). The FO's comments "oh" and "whoa," which expressed surprise, likely reflected his experience of one or both phenomena.

2.3.1.2 Other Factors Adversely Affecting Performance

Surprising events in the cockpit increase task demands on a pilot to resolve them (Lazarus and Folkman 1984). These types of events can also cause acute stress, which involves perceiving an immediate danger, and can trigger a "fight or flight" response (FAA 2016, 17-12). The effects

[49] Rapid deceleration would have the opposite effect, as the pilot may mistakenly think that the airplane is in a nose-down attitude.

[50] Research using a centrifugal simulator has shown that the introduction of accelerations conducive to somatogravic illusion interfered with pilot scanning and interpretation of primary flight displays (Cheung and Hofer 2003, 11-20).

of both surprise and stress can increase a pilot's perceived need to act while degrading the pilot's ability to accurately assess what needs to be done; this can result in impulsive and incorrect actions due to a physiological reaction known as a "startle response" (Landman et al 2017, 1161-72).

About the time the FO expressed surprise, he rapidly brought the control column to an almost neutral position, then pushed it forward again. This action could have constituted intentional testing behavior to see how relaxing forward pressure on the column affected sensations of motion, or it could have occurred reflexively as a result of a startle response. About this time, the combined effects of the changes in the airplane's motion resulted in changes to the GIF vector similar to what would occur if the airplane were descending vertically in a near-level pitch attitude, which likely produced a sensation of falling.

About this time, the FO exclaimed, "where's my speed" and "we're stalling," and continued to push the control column forward, exacerbating the airplane's dive. Although the FO declared that the airplane was stalling, the NTSB's airplane performance study found that the airplane's airspeed and wing AOA were not consistent with the airplane having been at or near a nose-high stalled condition. Further, the FO's response to excessively lower the nose of the airplane was contrary to standard procedures and training for responding to a stall, which prescribed first assessing the readily identifiable cues indicative of the airplane approaching an impending stall and disconnecting the automation. No such cues—such as stick shaker activation, stall warning annunciations, nose-high pitch indications (including those provided by the ADI's airplane attitude presentation and pitch limit indicator), and low airspeed indications—were present.

The NTSB's investigation found no evidence that any of the sources of airspeed and airplane pitch information available to the FO were malfunctioning; thus, the FO's comments about airspeed and stall indicate that he was not effectively scanning his instruments and interpreting the information they provided. The FO's attention appears to have been fully absorbed by the incorrect sensations of pitching up and falling, which, for him, were the most compelling cues in his environment, leading him to incorrectly conclude that the airplane was stalling. This would have reinforced his perceived need to continue nose-down control inputs.

The effects of sensory illusions, stress, and the startle response can adversely affect the performance of any pilot, and pilot training program and proficiency check requirements for Part 121 air carriers include emergency procedures scenarios intended to help a pilot develop and maintain the skills to appropriately assess and respond to a variety of stressful, startling scenarios. However, the accident FO had a history of training performance deficiencies in which he performed poorly in response to unexpected stressful events.[51] Various instructors and check airmen from throughout the FO's career described training scenarios in which the FO demonstrated low situational awareness, became overwhelmed, overcontrolled the airplane, made numerous mistakes, and responded impulsively with inappropriate actions.[52]

[51] Atlas was not aware of all the FO's training performance deficiencies (see sections 2.4.1 and 2.4.2).

[52] Impulsivity has been identified as an undesirable hazardous attitude that can affect a pilot's ability to make sound decisions. It is the perceived need to do something—anything—immediately. Pilots with impulsivity tend to act without thinking and do not select the best alternative (FAA 2008, 8-17).

Based on the FO's history of training performance deficiencies, the FO was susceptible to responding impulsively and inappropriately when faced with a stressful, unexpected event. Therefore, the NTSB concludes that, although compelling sensory illusions, stress, and startle response can adversely affect the performance of any pilot, the FO had fundamental weaknesses in his flying aptitude and stress response that further degraded his ability to accurately assess the airplane's state and respond with appropriate procedures after the inadvertent activation of the go-around mode.

2.3.2 Captain's Delayed Awareness and Ineffective Response

Like the FO, the captain had been expecting the airplane to automatically increase thrust and slightly increase pitch to level off at the MCP-selected altitude of 3,000 ft msl. The captain, as PM, was required to actively monitor the flight, including the airplane flightpath, automation status, and the FO's actions as PF. Effective monitoring and crosschecking are essential because detecting an error or unsafe situation can be the last line of defense to prevent an accident (FAA 2004, 14).

Based on the available CVR information, from before activation of the go-around mode until about 10 seconds after, the captain was setting up the approach to IAH on the FMC and communicating with ATC. While setting up the approach, the captain was likely head-down and concentrating on the FMC rather than monitoring the flight instruments or the FO's actions. This would reduce the captain's awareness of the airplane's automation status and energy state and could explain why the captain did not notice the "GA" indications on the flight mode annunciator or the EICAS or that the anticipated increase in airplane thrust began when the airplane was at a much higher-than-expected altitude.[53]

However, the captain's response to less subtle aspects of the developing situation, such as the FO's nose-down control column inputs associated with his spatial disorientation, were also delayed. Research has shown that a PM may be slow to take control when the PF is subtly incapacitated (for example, due to spatial disorientation) because the PM's recognition of something being wrong can be delayed if his or her attention is focused on normal operational tasks or if the deviation in performance is a surprise (Harper, Kidera, and Cullen 1971).[54]

As previously mentioned, at 1238:44, the FO said, "oh," indicating surprise, which was about 2 seconds after the captain's last routine radio communication to the controller and concurrent with the controller's response. It also occurred about 4 seconds after the cockpit's owl beeper sounded, which, based on the FDR data, likely indicated an autopilot caution alert (due to the opposing manual inputs on the control columns). At 1238:46 (about 15 seconds after the

[53] The thrust levers advanced slowly (taking about 7 seconds to advance about 50°) and were in the captain's visual periphery (human peripheral vision is more sensitive to rapid motion than slow motion). Further, the resulting gradual increase in engine power (which took about 11 seconds to reach go-around thrust due to engine spool-up time) may not have initially differed enough from the changes the captain had been expecting to have captured his attention.

[54] PM response delays in one study ranged from 30 seconds to 4 minutes (Harper, Kidera, and Cullen, 1971). In another study, pilots (both PF and PM) who encountered an unexpected abnormal event during simulator training took an average of 8.36 seconds to respond, with response times ranging from 1.9 to 18.2 seconds (Casner, Geven, and Williams 2013).

inadvertent activation of the go-around mode), the captain took hold of the left control column and started pulling back, countering the FO's continued nose-down control inputs. The NTSB concludes that, while the captain was setting up the approach and communicating with ATC, his attention was diverted from monitoring the airplane's state and verifying that the flight was proceeding as planned, which delayed his recognition of and response to the FO's unexpected actions that placed the airplane in a dive.

About the time that the captain took hold of the left control column and started pulling back, the thrust levers were abruptly reduced then advanced; however, it is unknown which crewmember took this action. The captain's action on the control column was not followed by the command "I have control" to indicate a positive transfer of control of the airplane, as required by Atlas procedures. As a result, the captain and the FO each continued to apply opposing forces on the elevator control columns, with the captain adding enough force to overcome the elevator system's control column override mechanism and split the positions of the elevators on each side. The captain's and the FO's opposing elevator control forces continued for about 10 seconds, during which the airplane's dive continued to steepen. Thus, the NTSB concludes that the captain's failure to command a positive transfer of control of the airplane as soon as he attempted to intervene on the controls enabled the FO to continue to force the airplane into a steepening dive.

Although the captain may have been trying to diagnose the situation and determine what corrective actions were needed, he likely experienced startle and surprise once he recognized that the airplane was in a dive, resulting in increased stress and reduced performance. Also, the situation was likely difficult for the captain to evaluate, considering that the FO's control inputs, the automated inputs, and external forces were each affecting control feel and airplane behavior.

Although the captain asked the FO what was happening, the FO made only panicked statements and was unable to provide the captain with any useful information. The captain was being subjected to the same stressful and disorienting accelerations as the FO, which could have degraded his ability to correctly interpret the instruments and identify the most appropriate course of action. When such situations occur unexpectedly, they can be ambiguous and confusing. The captain's failure to disconnect the autopilot or autothrottle, in keeping with Atlas' procedures, during any point in the accident sequence suggests that he had not fully processed the airplane's energy state, automation status, or the reason for the FO's actions.

Analysis of the available weather information determined that, once the airplane had descended through an altitude of about 3,000 ft msl (which corresponded with the expected cloud base heights for the area), it would have been exiting IMC; thus, the crew would have been able to clearly see the airplane's attitude and descending trajectory. About this time, both elevators began to move concurrently to an airplane nose-up position, attaining the full airplane nose-up position and remaining there until the end of the FDR recording.[55] Thus, it likely that both the FO and the captain were pulling back on the control columns to arrest the airplane's descent, but, by

[55] During this time, the position of the left elevator control column (for which the FDR recorded position data) matched the position of the elevators. Although it is possible that this can result from manual elevator control column inputs from only one crewmember, the evidence shows that previously (when the elevators were split), both the captain and the FO were applying (opposing) manual inputs on their respective controls. Thus, it is likely that the commanded transition of the elevators to the airplane nose-up position resulted from both the captain and the FO pulling back on their respective control columns.

this time, the situation was unrecoverable. Therefore, the NTSB concludes that the captain's degraded performance, which included his failure to assume positive control of the airplane and effectively arrest the airplane's descent, resulted from the ambiguity, high stress, and short timeframe of the situation.

2.4 Atlas' Evaluation of the First Officer

Atlas' pilot hiring procedures included an initial review of an application for minimum requirements, resume review, and initial telephone screening of the applicant with a recruiter before an interview would be scheduled. Although Atlas' hiring process included crosschecking to ensure that information provided on the application, during interviews, and in the background check all agreed, Atlas ultimately relied on the applicants' honesty in disclosing information.

During the hiring process, however, the accident FO did not disclose to Atlas all his previous employers and training failures. Atlas also did not fully evaluate all the information it received regarding the FO's training performance deficiencies at a previous employer. As a result, Atlas did not have a complete picture of the FO's career and training performance history to consider when it evaluated both his employment application and his performance in the company's own training program.

2.4.1 First Officer's Nondisclosure of Past Training Failures

When the FO applied for employment at Atlas, he did not disclose having worked for CommutAir in 2011 and Air Wisconsin Airlines in 2012, two airlines from which he resigned after not having completed initial training. Although his employment at CommutAir fell outside the 5-year reporting window required by the PRIA, his employment at Air Wisconsin Airlines did not. However, the FO's resume included his employment with another airline (for which he successfully completed training and worked for 2 years), even though his employment there fell outside the PRIA reporting requirements. In addition, when the FO applied to Trans States Airlines in 2014, he did not disclose his previous employment with Air Wisconsin, even though such employment occurred within the 5-year PRIA reporting requirement (see table).

Table. First officer's former employers and training difficulties.

Former Employer (year employed)	Within PRIA 5-Year Disclosure Requirement?	FO Disclosed Employment to Atlas?	Training Difficulty
Mesa (2015-2017)	Yes	Yes	Embraer ERJ175: Unsuccessful attempt to upgrade to captain
Trans States (2014)	Yes	Yes	Embraer ERJ145: Failed oral examination, failed ATP checkride, unsatisfactory line check
Charter Air Transport (2013-2014)	Yes	Yes	
Air Wisconsin (2012)	Yes	No	Canadair Regional Jet: Did not complete FO initial training
CommutAir (2011)	No	No	deHavilland DHC-8: Did not complete FO initial training
Air Turks and Caicos (2008 to 2010)	No	Yes	

The FO's repeated omission of certain former employers from his resume suggests deception, likely to prevent potential employers from discovering his history of performance deficiencies and using that information as a basis to reject his employment application. The FO showed further deception on his Atlas application by attributing gaps in his employment history to college, furlough, and other nonairline work without mentioning his time spent at CommutAir and Air Wisconsin.

Moreover, in response to a question about past failures, the FO did not disclose his unsuccessful attempt to upgrade to captain at Mesa Airlines. (Although this information was contained in training records provided by Mesa Airlines, it was ambiguous, and Atlas personnel did not recognize it; see section 2.4.2.) These deceptive omissions prevented potential employers, including Atlas, from considering the FO's entire training history during the hiring process. Thus, the NTSB concludes that the FO's repeated uses of incomplete and inaccurate information about his employment history on resumes and applications were deliberate attempts to conceal his history of performance deficiencies and deprived Atlas and at least one other former employer of the opportunity to fully evaluate his aptitude and competency as a pilot.

2.4.2 Atlas' Review of Available Training Records

Atlas used a third-party DA to obtain and review background records for pilot applicants in accordance with the PRIA. According to AC 120-68H, a hiring operator may use a DA to obtain pilot records, but the operator is ultimately responsible for evaluating those records (FAA 2017, 3.1). Atlas' HR director said that, as part of the hiring decision-making process, both the DA vendor and Atlas' HR personnel would review PRIA records for significant items of concern or "red flags" and bring them to the attention of Atlas' director of training.

The FO's training records made available to Atlas under the PRIA included information about his unsuccessful attempt to upgrade to captain on the Embraer ERJ175 at Mesa Airlines, which occurred just 2 months before Atlas hired him. A pilot's unsuccessful upgrade on the same airplane that he or she had been flying for several years is a significant event for a hiring operator to evaluate, particularly when it is a recent occurrence. However, neither the DA vendor nor Atlas' HR personnel identified the record of the FO's unsuccessful upgrade attempt as a "red flag" item to be brought to the attention of Atlas' director of training. As a result, no one at Atlas followed up with the FO or Mesa Airlines to further evaluate the event before hiring the FO; the FO had already begun Atlas' initial training and had started Boeing 767 full-flight simulator training at the time the records were obtained.

Atlas' HR director said the record of the FO's unsuccessful upgrade attempt was not reported by Mesa Airlines as a training "failure" but rather with a statement that he was "returning to FO." She said that, in hindsight, she could see the statement referred to unsuccessful captain upgrade training. She said she believed that the DA should have identified such a training event in an applicant's records as a "red flag." The director of training said that, in reviewing the record after the accident, the information provided by Mesa Airlines was vague and should have been identified for additional follow-up.

The NTSB notes that DA and HR personnel who are authorized to retrieve background records may not be pilots, may be unfamiliar with pilot training processes, and/or may lack extensive training backgrounds in airline operations. In this case, neither the DA nor Atlas' HR director recognized a significant substandard training event that was not explicitly labeled as a "failure" in the record; however, the airline is responsible for thoroughly evaluating the records it receives. Thus, the NTSB concludes that Atlas' HR personnel's reliance on DAs to review pilot background records and flag significant items of concern was inappropriate and resulted in the company's failure to evaluate the FO's unsuccessful attempt to upgrade to captain at his previous employer.

After the accident, Atlas made several improvements to its pilot-hiring process, including having a member of the flight operations team review each applicant's background records to provide an additional technical perspective to the candidate-vetting process. The NTSB believes that such a measure will help to ensure that any significant substandard training events are identified for evaluation. Thus, the NTSB concludes that operators that rely on DAs or HR personnel for initial review of records obtained under the PRIA should include flight operations subject matter experts early in the records review process. Therefore, the NTSB recommends that the FAA inform Part 119 certificate holders, air tour operators, fractional ownership programs, corporate flight departments, and governmental entities conducting public aircraft operations about the hiring process vulnerabilities identified in this accident, and revise AC 120-68H, "Pilot Records Improvement Act and Pilot Records Database," to emphasize that operators should include flight operations subject matter experts early in the records review process and ensure that significant training issues are identified and fully evaluated.

2.4.3 Remedial Training and Performance Monitoring

Atlas had a remedial training protocol and a PWP that complied with the 14 *CFR* 121.415 requirements for tracking performance deficiencies and remedial training. Atlas' fleet captain had wide discretion in determining what remedial training to assign to help a pilot with demonstrated deficiencies return to a satisfactory level of performance.[56] Such remedial training could include a records review, additional training, and/or counseling.

After the accident FO completed Atlas' basic indoctrination training and Boeing 767 ground school, he was assigned and completed remedial training to address weaknesses in his knowledge of airplane takeoff and landing performance and airplane systems, and he subsequently passed his oral examination. He was also assigned remedial training in the fixed-base simulator on performing normal procedures, which he successfully completed before he was recommended to progress to the Boeing 767 full-flight simulator.

The FO began full-flight simulator training on August 10, 2017. However, after two sessions, the FO's simulator partner complained that he was being held back by the FO. According to the fleet captain, at the time, Atlas did not have staff available to continue the FO's simulator training, so his simulator training sessions were restarted from the beginning on August 27, 2017.[57]

On September 3, 2017, after the FO had completed his sixth training session, the effects of a hurricane forced Atlas to shut down all training. The FO's training did not resume until September 19, 2017, and he failed his practical Boeing 767 type-rating examination 3 days later. The examiner who observed the FO described him as having been very nervous and said the FO demonstrated "very low" situational awareness, poor CRM, and a tendency to take inappropriate action when he perceived the need to do something. The examiner said the FO's performance was so poor that he was concerned that the FO would be unable to "mentally recover" enough to complete the course. However, after receiving remedial training on September 25, 2017, the FO passed the type-rating checkride the next day. The Atlas instructor who performed the FO's remedial training described it as a "great training session" and said he thought the FO had a confidence problem.

When evaluating the FO's initial training difficulties, Atlas' fleet captain considered factors that he believed may have adversely affected the FO's performance, including the training schedule interruptions (which were beyond the FO's control), family issues the FO was experiencing, and the FO's potential nervousness during the checkride due to the presence of an FAA examiner. For these reasons, the fleet captain chose to monitor the FO's operating experience when considering whether the FO should be placed in the PWP. The FO subsequently completed 53 hours of initial operating experience, all of which was completed with an Atlas check airman, and he demonstrated no difficulties with his subsequent recurrent training at Atlas.

For reasons discussed previously in sections 2.4.1 and 2.4.2, Atlas' director of training was unaware of the FO's previous failures to complete initial training at two other airlines and his unsuccessful attempt to upgrade to captain at a third; however, it is not known how this information would have affected Atlas' evaluation of the FO's hiring application or his performance in its own initial training program. Based on the FO's total flight hours, experience at Part 121 air carriers,

[56] Atlas modified its PWP before the FO was hired to include a more subjective review of a pilot's training and to exclude a single failure as a triggering event.

[57] The fleet captain said that he decided to split up the FO and his partner. He said that, due to constraints with both simulator and instructor availability (because of a scheduled meeting attended by all Atlas instructors), Atlas was unable to immediately continue the FO's training.

and experience in turbine-powered airplanes, he met Atlas' criteria for a highly competitive applicant and was rated "highly recommended" during the hiring process. Although the average total flight experience for newly hired pilots at Atlas had decreased in recent years, the FO's experience far exceeded Atlas' minimum requirements, and there was no evidence that Atlas was under any pressure to hire or retain any pilot with whom it had any performance or other safety concerns.

2.5 Industry Pilot Hiring Process Deficiencies

2.5.1 Limitations of the Retrieval Process for Background Records

The manual process by which a hiring operator (or DA) retrieves background records under the PRIA currently involves requesting the records directly from each former employer disclosed by a pilot applicant. Thus, if a pilot intentionally omits a previous employer, as the FO did, the hiring operator may never know the pilot's complete background.

Further, variations in how the airline industry defines the employment status of newly hired pilots could present another challenge for hiring operators. Some operators may consider a pilot as employed once that pilot enters basic indoctrination training while others may not make that distinction until the pilot completes training and becomes line-qualified. Pilots who are unable to complete initial training due to poor performance are commonly allowed the opportunity to resign rather than be terminated from employment. Thus, the NTSB concludes that the manual process by which PRIA records are obtained could preclude a hiring operator from obtaining all background records for a pilot applicant who fails to disclose a previous employer due to either deception or having resigned before being considered fully employed, such as after starting but not completing initial training.

Ten years ago, Section 203 of the *Airline Safety and Federal Aviation Administration Extension Act of 2010* mandated that the FAA create an electronic pilot records database (PRD), which was intended to improve the timeliness and efficiency of the PRIA records retrieval process by providing hiring operators and DAs with direct access to pilots' FAA, NDR, and former employer records in a single database. By 2016, the FAA had not yet implemented the PRD, and Congress imposed an April 30, 2017, deadline, which the FAA also missed. Although the FAA has begun phasing in the use of the PRD, the PRD is not yet fully functional; it contains only pilots' FAA records and is available to hiring operators for use on a voluntary basis.

On March 30, 2020, the FAA published a notice of proposed rulemaking (NPRM) that outlined PRD functions. These included providing all pilots' records electronically from the FAA, NDR, and former employers, to include Part 119 certificate holders, air tour operators, fractional ownership programs, corporate flight departments (the inclusion of which is proposed in the NPRM), and governmental entities conducting public aircraft operations (FAA 2020c, 17660-720). On June 16, 2020, the NTSB provided comments to the FAA stating that we generally support the FAA's planned actions outlined in the NPRM.[58] According to the NPRM, the applicable operators that employ pilots will be required to report to the electronic PRD various specified records pertaining to the individual's performance as a pilot, including those concerning any release from employment, resignation, termination, or disqualification with respect to employment.

The NPRM also stated that an individual's hire date will be defined as "the earliest date on which an individual is expected to begin any form of company required training" and proposes to require that each operator report records for that individual "employed as a pilot beginning on the PRD date of hire." The NTSB believes that these definitions are critical for ensuring that the PRD will include records from operators at which a pilot started but never completed initial training before leaving the company.

Also, the NPRM stated that the PRD records will be searchable by a pilot's certificate number, which the NTSB believes is a critical feature that should be incorporated into the final rule to enable a hiring operator to obtain all background records for a pilot reported by all previous employers, even if the pilot fails to disclose some employers, as was the case with the accident FO. Thus, the NTSB concludes that, had the FAA met the deadline and complied with the requirements for implementing the PRD as stated in Section 203 of the *Airline Safety and Federal Aviation Administration Extension Act of 2010*, the PRD would have provided hiring employers relevant information about the FO's employment history and training performance deficiencies. Therefore, the NTSB recommends that the FAA implement the PRD and ensure that it includes all industry records for all training started by a pilot as part of the employment process for any Part 119 certificate holder, air tour operator, fractional ownership program, corporate flight department, or governmental entity conducting public aircraft operations regardless of the pilot's employment status and whether the training was completed. The NTSB also recommends that the FAA ensure that industry records maintained in the PRD are searchable by a pilot's certificate number to enable a hiring operator to obtain all background records for a pilot reported by all previous employers.

In the past 32 years, the NTSB has repeatedly addressed the hazards posed by pilots with a history of performance difficulties by recommending measures to ensure more thorough examinations of a pilot applicant's employment history and closer monitoring of pilots who experience problems during training.[59] NTSB recommendations in these areas, which resulted from the NTSB's investigation of numerous accidents involving flight crewmembers who experienced multiple past training failures, resulted in enhanced background screening processes

[58] Comments on the NPRM from the NTSB and others can be found in FAA docket FAA-2020-0246, which can be searched from the Regulations.gov web page at https://www.regulations.gov.

[59] See appendix C for the NTSB's safety recommendations.

under the PRIA and increased airline oversight of pilots who struggle during training (such as the PWP).[60]

Although the FAA and other recipients have taken responsive action to satisfy several NTSB recommendations, other recommendations to the FAA have remained open for 10 to 15 years. These include Safety Recommendation A-05-1, which asked the FAA to “[r]equire all Part 121 and 135 air carriers to obtain any notices of disapproval for flight checks for certificates and ratings for all pilot applicants and evaluate this information before making a hiring decision”; Safety Recommendation A-10-17, which asked the FAA to “[r]equire…Part 121, 135, and 91K operators to document and retain electronic and/or paper records of pilot training and checking events in sufficient detail so that the carrier and its principal operations inspector can fully assess a pilot’s entire training performance”; Safety Recommendation A-10-19, which asked the FAA to “[r]equire…Part 121, 135, and 91K operators to provide the training records requested in Safety Recommendation A-10-17 to hiring employers to fulfill their requirement under the Pilot Records Improvement Act”; and Safety Recommendation A-10-20, which asked the FAA to “[d]evelop a process for verifying, validating, auditing, and amending pilot training records at…Part 121, 135, and 91K operators to guarantee the accuracy and completeness of the records.” Due to the FAA’s failure to complete timely responsive action, the NTSB reiterates Safety Recommendations A-05-1, A-10-17, A-10-19, and A-10-20 and classifies each “Open—Unacceptable Response” in this report.

2.5.2 Need for Improved Pilot Selection and Performance Measurement Methods

The accident investigation’s review of records from all of the FO’s previous employers (not all of which the FO disclosed to Atlas and other airlines for which he had worked) determined the FO had a long-term history of training program failures that spanned multiple employers and multiple airplane types. This pattern of failures indicated significant performance deficiencies and was indicative of a pilot with aptitude-related performance difficulties.

Although the FO was able to successfully perform highly proceduralized actions during training when given enough practice, he repeatedly demonstrated that he would become overwhelmed when confronted with novel, compounding, or unexpected situations. Such situations require complex cognitive processing to determine an appropriate response. The dominant predictor of success with such tasks is general cognitive ability, a trait long considered a core aspect of aviation aptitude (Ackerman 1988, 288-318; Ree and Carretta 2009, 111-23). The

[60] These accidents included the 1987 crash of a McDonnell Douglas DC-9-14 (operated by Continental Airlines Inc.) in Denver, Colorado (NTSB 1988); the April 1993 crash of a McDonnell Douglas DC-10-30 (operated by American Airlines) at Dallas/Fort Worth International Airport, Texas (NTSB 1994a); the December 1993 crash of a Jetstream BA-3100 (operated by Express II Airlines Inc./Northwest Airlink) in Hibbing, Minnesota (NTSB 1994b); the December 1994 crash of a BAe Jetstream 2201 (operated by Flagship Airlines, Inc., dba American Eagle) in Morrisville, North Carolina (NTSB 1995b); the October 2002 crash of a Raytheon (Beechcraft) King Air A100 (operated by Aviation Charter Inc.) in Eveleth, Minnesota (NTSB 2003); the July 2003 crash of a Cessna 402C (operated by Air Sunshine Inc.) near Great Abaco Island, Bahamas (NTSB 2004); the 2003 crash of a Boeing MD-10-10F (operated by Federal Express) in Memphis, Tennessee (NTSB 2005); the 2009 crash of a Bombardier DHC-8-400 (operated by Colgan Air Inc. as Continental Connection) in Clarence Center, New York (NTSB 2010); the November 2015 crash of a British Aerospace HS 125-700A (operated by Execuflight) in Akron, Ohio (NTSB 2016); and the May 2017 crash of a Learjet 35A (operated by Trans-Pacific Air Charter LLC) in Teterboro, New Jersey (NTSB 2019).

FO's pattern of difficulties in training suggests that he may have been weak in this area.[61] Therefore, the NTSB concludes that the FO's long history of training performance difficulties and his tendency to respond impulsively and inappropriately when faced with an unexpected event during training scenarios at multiple employers suggest an inability to remain calm during stressful situations—a tendency that may have exacerbated his aptitude-related performance difficulties.

As stated in the previous section, the NTSB has repeatedly recommended measures to ensure more thorough examinations of a pilot applicant's employment history and closer monitoring of pilots who experience problems during training. However, despite some improvements in background screening processes and airline training programs over the years, the accident FO was able to secure employment, complete training, and work as a pilot at several airlines. This suggests that existing industry pilot selection processes and performance measurement methods may have weaknesses when it comes to identifying pilots whose cognitive characteristics may be unsuitable for such a career.

To mitigate the risk of hiring unsuitable pilots, airlines need a systematic, scientifically based approach to the pilot selection process. Psychological theory and data have informed the scientific community's understanding of the relationship between individual differences and human performance in different work-related contexts. This understanding provided a foundation for the development of an effective selection system. Such a system can be systematically developed using a series of steps described in professional guidelines upon which FAA researches have elaborated (SIOP 2018; Broach, Gildea, and Schroeder 2019). These steps include the following:

1. Conduct a job analysis;
2. Define measurable, observable job performance metrics;
3. Identify and use reliable and valid predictors;
4. Conduct an appropriate validation study;
5. Determine cut-scores (pass/fail) on tests based on predicted job performance;
6. Evaluate the fairness of tests and cut-scores; and
7. Document the analyses.

A 2012 report on a survey of airlines by the International Air Transport Association (IATA) concluded that only a minority of airlines had a "structured and scientifically based" selection system (IATA 2012). A 2019 report by FAA researchers on airline selection practices identified pilot selection as a "critical human resource management challenge" for operators that is hindered by a lack of available documentation on airline pilot selection processes, most of which is "hidden behind corporate firewalls" (Broach, Gildea, and Schroeder 2019). In their report, the FAA researchers urged the sharing of data among airlines about the effectiveness of different selection

[61] The FO's aptitude-related performance difficulties may also have been exacerbated by performance-related anxiety, which can involve acting impulsively without rational thought or reason and a reduced ability to learn from perceptions (FAA 2008); however, little information about the FO's emotional characteristics were available.

methods for predicting pilot success. Increasing the availability of such information among airlines could help facilitate the development of best practices.

Once a newly hired pilot enters initial training, evaluators (including those at Atlas) commonly use rating forms for each training event that involves performance checks. Each form lists many items that are rated as “satisfactory” or “unsatisfactory,” and these items are used to determine an overall evaluation of a pilot’s performance. Some items describe the criteria for certain flight maneuvers, while others describe more general skills. Although practical test standards contain objective criteria for determining the successful performance for some items, the rating of some items depend on the subjective assessment by the evaluator. Research has indicated that such performance ratings are vulnerable to a range of shortcomings that can affect their reliability and validity (Landy and Farr 1980; Holt, Hansberger, and Boehm-Davis 2002).

In the 2019 report, FAA researchers also urged that airlines make improvements in the quality of their predictive and performance measures used to assess pilots, both in training and in the operational environment. To facilitate identifying such measures, the researchers encouraged the sharing of information among airlines about what works through the establishment of a clearinghouse of deidentified pilot selection data, modeled after other confidential safety data sharing initiatives like the Aviation Safety Information and Analysis Sharing (ASIAS) and the Flight Operations Quality Assurance (FOQA) programs. Such a clearinghouse, which might include anonymized pilot background and experience data, psychometric test scores, subjective and objective measures of performance during preemployment simulator evaluations, and measures of performance in training and on the job, could allow airlines to pool resources to conduct validation studies and share best practices for commercial pilot selection while protecting the privacy of the pilots upon whom the research is based.

The FAA researchers speculated that airlines might be reluctant to join such an effort because airlines may view selection programs as a source of competitive advantage over other airlines. However, the NTSB believes that the existence of certain weaknesses in airline pilot selection systems, such as those identified in this accident, is a matter of public safety and that airlines and the FAA should cooperate to develop scientifically based best practices for pilot selection and performance measurement.

Therefore, the NTSB concludes that the establishment of a confidential voluntary data clearinghouse to share deidentified pilot selection data among airlines about the utility of different methods for predicting pilot success in training and on the job would benefit the safety of the flying public. Therefore, NTSB recommends that the FAA establish a confidential voluntary data clearinghouse of deidentified pilot selection data that can be used to conduct studies useful for identifying effective, scientifically based pilot selection strategies. This program should be modeled after programs like ASIAS and FOQA.

2.6 Considerations for Automated Flight Systems

2.6.1 Awareness Information for Pilots of Boeing 767- and 757-Series Airplanes

Review of data from ASRS reports, The Boeing Company, Atlas, and one other airline found no other known events involving inadvertent activation of the go-around mode on a Boeing 767-series airplane due to unintended contact with a go-around switch. This suggests that such an event on the Boeing 767-series airplane may be rare or may simply go unreported. The expected response to an unintended automation change would be for the pilot to disconnect the automation and return the airplane to its original profile. For such a scenario, a pilot may feel no need to file a voluntary safety report for something considered benign and easily corrected, particularly if the pilot recognized that the activation resulted from unintended contact with the switch, and it did not lead to an undesirable aircraft state or flight path deviation.[62]

Thus, although the available data suggest that inadvertent activation of the go-around mode on Boeing 767-series airplanes may be a rare and typically benign event, the NTSB concludes that all pilots of Boeing 767- and 757-series airplanes (which share a similar go-around switch design) could benefit from an awareness of the circumstances of this accident that likely led to the inadvertent activation of the go-around mode. Therefore, the NTSB recommends that the FAA issue a safety alert for operators to inform pilots and operators of Boeing 767- and 757-series airplanes about the circumstances of this accident and alert them that, due to the close proximity of the speedbrake lever to the left go-around mode switch, it is possible to inadvertently activate the go-around mode when manipulating or holding the speedbrake lever as a result of unintended contact between the hand or wrist and the go-around switch.

2.6.2 Adaptations for Automatic Ground Collision Avoidance Technology

As previously stated, the accident FO likely experienced a somatogravic illusion, a form of spatial disorientation involving a pitch-up illusion. Previous accidents involving transport-category airplane pilots experiencing this phenomenon have occurred worldwide, resulting in hundreds of fatalities. These included the following:

- 1994 crash of a Douglas DC-9-31 (operated by USAir) in Charlotte, North Carolina, in which 37 people died and 16 were seriously injured (NTSB 1995a);
- 2000 crash of an Airbus A320-212 (operated by Gulf Air) in Muharraq, Bahrain, in which 143 people died (AIBB 2002);

[62] Further, for the 11 reported events that involved other transport-category airplane models, most were managed by the flight crews without serious safety-related consequences. As described in section 1.10.1, the NTSB and FAA have longstanding concerns about vulnerabilities in flight crew mode awareness and mode confusion errors. Although the NTSB is aware of two 1994 accidents and a 1989 incident involving other transport-category airplane models in which the sequence of events included inadvertent activation of the go-around mode, the investigations of those events—much like this accident investigation—identified multiple crew-related issues and other compelling factors that followed the unexpected automation change and resulted in an adverse outcome.

- 2006 crash of an Airbus A320-200 (operated by Armavia Airlines) in Sochi, Russia, in which 113 people died (AAICR 2007);
- 2010 crash of an Airbus A330-202 (operated by Afriqiyah Airways) in Tripoli, Libya, in which 103 people died and 1 was seriously injured (LCAA 2013);
- 2013 crash of a Bombardier CRJ-200 (operated by SCAT Airlines) near Kyzyltu, Kazakhstan, in which 21 people died (AAICR 2015);
- 2013 crash of a Boeing 737-500 (operated by Tatarstan Airlines) in Kazan, Russia, in which 50 people died (AAICR 2019a); and
- 2016 crash of a Boeing 737-8KN (operated by Flydubai) in Rostov-on-Don, Russia, in which 62 people died (AAICR 2019b).

The investigations of many of these accidents concluded that the somatogravic illusion was incapacitating for the pilots and identified a variety of contributing factors, such as limited external visual references, procedural noncompliance, stress, fatigue, distraction, low experience in the airplane type, conflicting control inputs, CRM deficiencies, and lack of understanding of the automation.

The accident investigations and various studies have resulted in safety recommendations intended to prevent accidents involving spatial disorientation due to somatogravic illusions. These included recommendations for changes in pilot training, standard operating procedures, display design, flight control system design, and ATC procedures.

One study that examined flight crew loss of airplane state awareness also identified common themes, including lack of external visual references, pilot training, distraction, CRM deficiencies, automation confusion, and ineffective alerting. This study led to recommendations for enhanced crew training, spatial disorientation detection and alerting systems, and improved cockpit displays of automation and the external environment (CAST 2014). Although these recommended solutions can help reduce spatial disorientation accidents involving somatogravic illusions, many have yet to be implemented, and most rely primarily on the flight crew to either avoid or recover from an aircraft upset.

In contrast, the US Department of Defense (DoD) has pursued a technological approach that could represent a more comprehensive solution to spatial disorientation accidents. In 2014, the DoD began equipping some F-16 fighter airplanes with an auto GCAS, which uses sensors, on-board monitors, and flight data to determine if an airplane is on course for a probable ground collision; based on the airplane's trajectory, speed, and a lack of input from the pilot, the system calculates the best way to recover. As of June 2018, auto GCAS has been credited with preventing the loss of seven aircraft and eight pilots (Dyer 2019).

Substantial progress has been made in the development and use of auto GCAS for fighter airplanes. Research continues to advance the design and testing efforts to develop an auto GCAS for use on performance-limited airplanes (which, generally, are less maneuverable and have lower power-to-weight ratios), such as the Lockheed C-130 (Gahan 2019, 1). One study found that auto

GCAS could have prevented at least 5 of the 31 ground collision accidents involving Lockheed C-130s, saving 34 lives and $385,000,000 in hull losses (Gahan 2019, 3). In collaboration with NASA, the DoD is also studying application of auto GCAS technology to autonomous aircraft and, based on that framework, plans to begin flight tests using a general aviation airplane in 2020 (NASA 2019).

The NTSB notes that a successful adaptation of an auto GCAS system on a military performance-limited airplane could have relevance for the safety of flight operations involving civil transport-category airplanes. Further, such an application would be consistent with recent trends for civil aviation, such as automatic landing technology, for which the FAA granted the first certification for use in civil general aviation airplanes in 2020 (Thurber 2020).

Thus, the NTSB concludes that the DoD has developed approaches to auto GCAS technology for fighter airplanes that, if successfully adapted for use in lower-performance, less-maneuverable airplanes, could serve as a model for the development of similar installations in civil transport-category airplanes that could dramatically reduce terrain collision accidents involving pilot spatial disorientation. Therefore, the NTSB recommends that the FAA convene a panel of aircraft performance, human factors, and aircraft operations experts to study the benefits and risks of adapting military auto GCAS technology for use in civil transport-category airplanes and make public a report on the committee's findings.

2.7 Cockpit Image Recorders

Several circumstances of this accident could not be conclusively determined, including how the go-around mode was inadvertently activated, the nature of the FO's display anomaly, the FO's display indications while he was spatially disoriented, the flight control inputs commanded by each crewmember, and the captain's focus of attention throughout the accident sequence. Further, the accident airplane's FDR was subject to grandfathered rules that required it to record a minimum of 34 parameters, whereas current rules require a minimum of 88 parameters; thus, the FDR data for the accident airplane lacked parameters that are currently required and would have assisted in this investigation. An image recorder with a properly placed flight deck camera system could have provided this valuable information, possibly enabling the identification of additional safety issues and the development of safety recommendations to prevent similar accidents.

Safety Recommendations A-15-7 and A-15-8 asked the FAA to require a cockpit image recording system compliant with Technical Standard Order TSO-C176a, "Cockpit Image Recorder Equipment," (or equivalent) as a retrofit on existing airplanes and as an installation on newly built airplanes, respectively, that are operated under Part 121 or Part 135. These recommendations superseded Safety Recommendations A-00-30 and -31 issued 20 years ago.

In its September 21, 2018, response to Safety Recommendations A-15-7 and -8, the FAA indicated that it would not require aircraft to be equipped with a cockpit image recording system, as recommended, but that it was considering requiring the installation of an expanded data recorder consistent with the International Civil Aviation Organization's (ICAO) updated Annex 6 recorder parameter requirements that were incorporated in ICAO amendment 43, which mandated that, after January 1, 2023, aircraft over 27,000 kg (59,525 lbs) must record information displayed to the flight crew from electronic displays, as well as the operation of switches and selectors by the flight crew. The FAA provided the NTSB an update on June 12, 2020, that said it was considering the feasibility of requiring all newly built aircraft that are operated under Part 121 or Part 135 and required to have a CVR and a FDR also be equipped with a crash-protected screen capture recording system.[63]

The NTSB has not yet responded to the FAA's most recent letter; however, on December 13, 2018, we informed the FAA of an evaluation we conducted to determine whether requiring the updated recorder parameters contained in ICAO amendment 43 represented an alternative course of action that would satisfy these recommendations. Our evaluation reviewed eight accidents and incidents that were the basis for Safety Recommendations A-00-30 and -31 and A-15-7 and -8 and considered for each accident, 1) what needed information was not available but would have been provided by cockpit image recorders compliant with TSO-C176a, and 2) whether recorders compliant with ICAO amendment 43 would have provided the needed information. While recorders compliant with ICAO amendment 43 would have provided sufficient information for three of the eight accidents and incidents, for the remaining five events, only the TSO-C176a-compliant cockpit image recorders would have provided the information necessary to fully understand what led to the event. Based on this evaluation, the NTSB informed the FAA that requiring ICAO amendment 43-compliant recorders would not satisfy Safety Recommendations A-15-7 and -8, which were classified "Open—Unacceptable Response."

The circumstances of this accident illustrate why an expanded data recorder that records the position of various knobs, switches, flight controls, and information from electronic displays is not an acceptable alternative to TSO-C176a-compliant cockpit image recorders. Some questions in this accident, including how the go-around mode was activated, what happened to the FO's displays that prompted him to use the EFI switch, and where the captain's and FO's focus was directed during critical points in the accident sequence would not be answered with additional parametric or display data. Therefore, the NTSB concludes that an expanded data recorder that records the position of various knobs, switches, flight controls, and information from electronic displays, as specified in amendment 43 to the recorder standards of the ICAO, would not have provided pertinent information about the flight crew's actions.

The NTSB does not object to further data requirements for information that is included in FDRs and CVRs; in fact, many current FDR installations already record some or all the expanded data mentioned in the FAA's September 2018 response to Safety Recommendations A-15-7 and A-15-8. However, these extra parameters would not have aided investigators in the way that flight deck images would have. The NTSB concludes that a flight deck image recording system compliant with TSO-C176a would have provided relevant information about the data available to the flight crew and the flight crew's actions during the accident flight. Therefore, the NTSB reiterates Safety Recommendations A-15-7 and A-15-8 to the FAA, recommending the retrofit or installation of TSO-C176a-compliant (or equivalent) cockpit image recorder technology on all aircraft operated under Part 121 or 135 and currently required to have a CVR and an FDR.

[63] Summarized correspondence for safety recommendations (including A-15-7 and -8) can be accessed from the NTSB's Aviation Information Resources web page.

3. Conclusions

3.1 Findings

1. None of the following were factors in this accident: (1) the captain's and the first officer's certifications and qualifications; (2) air traffic control services; (3) the condition and maintenance of airplane structures, powerplants, and systems; and (4) airplane weight and balance.

2. There was insufficient information to determine whether the flight crewmembers were fatigued at the time of the accident, and no available evidence suggested impairment due to any medical condition, alcohol, or other impairing drugs.

3. Whatever electronic flight instrument system display anomaly the first officer (FO) experienced was resolved to both crewmembers' satisfaction (by the FO's cycling of the electronic flight instrument switch) before the events related to the accident sequence occurred.

4. The activation of the airplane's go-around mode was unintended and unexpected by the pilots and occurred when the flight was encountering light turbulence and likely instrument meteorological conditions associated with its penetration of the leading edge of a cold front.

5. Presuming that the first officer (FO) was holding the speedbrake lever as expected in accordance with Atlas Air Inc.'s procedure, the inadvertent activation of the go-around mode likely resulted from unintended contact between the FO's left wrist or watch and the left go-around switch due to turbulence-induced loads that moved his arm.

6. Despite the presence of the go-around mode indications on the flight mode annunciator and other cues that indicated that the airplane had transitioned to an automated flight path that differed from what the crew had been expecting, neither the first officer nor the captain were aware that the airplane's automated flight mode had changed.

7. Given that the first officer (FO) was the pilot flying and had not verbalized any problem to the captain or initiated a positive transfer of airplane control, the manual forward elevator control column inputs that were applied seconds after the inadvertent activation of the go-around mode were likely made by the FO.

8. The first officer likely experienced a pitch-up somatogravic illusion as the airplane accelerated due to the inadvertent activation of the go-around mode, which prompted him to push forward on the elevator control column.

9. Although compelling sensory illusions, stress, and startle response can adversely affect the performance of any pilot, the first officer had fundamental weaknesses in his flying aptitude and stress response that further degraded his ability to accurately assess the

airplane's state and respond with appropriate procedures after the inadvertent activation of the go-around mode.

10. Had the Federal Aviation Administration met the deadline and complied with the requirements for implementing the pilot records database (PRD) as stated in Section 203 of the *Airline Safety and Federal Aviation Administration Extension Act of 2010*, the PRD would have provided hiring employers relevant information about the first officer's employment history and training performance deficiencies.

11. The first officer's long history of training performance difficulties and his tendency to respond impulsively and inappropriately when faced with an unexpected event during training scenarios at multiple employers suggest an inability to remain calm during stressful situations—a tendency that may have exacerbated his aptitude-related performance difficulties.

12. While the captain was setting up the approach and communicating with air traffic control, his attention was diverted from monitoring the airplane's state and verifying that the flight was proceeding as planned, which delayed his recognition of and response to the first officer's unexpected actions that placed the airplane in a dive.

13. The captain's failure to command a positive transfer of control of the airplane as soon as he attempted to intervene on the controls enabled the first officer to continue to force the airplane into a steepening dive.

14. The captain's degraded performance, which included his failure to assume positive control of the airplane and effectively arrest the airplane's descent, resulted from the ambiguity, high stress, and short timeframe of the situation.

15. The first officer's repeated uses of incomplete and inaccurate information about his employment history on resumes and applications were deliberate attempts to conceal his history of performance deficiencies and deprived Atlas Air Inc. and at least one other former employer of the opportunity to fully evaluate his aptitude and competency as a pilot.

16. Atlas Air Inc.'s human resources personnel's reliance on designated agents to review pilot background records and flag significant items of concern was inappropriate and resulted in the company's failure to evaluate the first officer's unsuccessful attempt to upgrade to captain at his previous employer.

17. Operators that rely on designated agents or human resources personnel for initial review of records obtained under the Pilot Records Improvement Act should include flight operations subject matter experts early in the records review process.

18. The manual process by which Pilot Records Improvement Act records are obtained could preclude a hiring operator from obtaining all background records for a pilot applicant who fails to disclose a previous employer due to either deception or having resigned before being considered fully employed, such as after starting but not completing initial training.

19. The establishment of a confidential voluntary data clearinghouse to share deidentified pilot selection data among airlines about the utility of different methods for predicting pilot success in training and on the job would benefit the safety of the flying public.

20. All pilots of Boeing 767- and 757-series airplanes (which share a similar go-around switch design) could benefit from an awareness of the circumstances of this accident that likely led to the inadvertent activation of the go-around mode.

21. The Department of Defense has developed approaches to automatic ground collision avoidance system technology for fighter airplanes that, if successfully adapted for use in lower-performance, less-maneuverable airplanes, could serve as a model for the development of similar installations in civil transport-category airplanes that could dramatically reduce terrain collision accidents involving pilot spatial disorientation.

22. An expanded data recorder that records the position of various knobs, switches, flight controls, and information from electronic displays, as specified in amendment 43 to the recorder standards of the International Civil Aviation Organization, would not have provided pertinent information about the flight crew's actions.

23. A flight deck image recording system compliant with Technical Standard Order TSO-C176a, "Cockpit Image Recorder Equipment," would have provided relevant information about the data available to the flight crew and the flight crew's actions during the accident flight.

3.2 Probable Cause

The NTSB determines that the probable cause of this accident was the inappropriate response by the first officer as the pilot flying to an inadvertent activation of the go-around mode, which led to his spatial disorientation and nose-down control inputs that placed the airplane in a steep descent from which the crew did not recover. Contributing to the accident was the captain's failure to adequately monitor the airplane's flightpath and assume positive control of the airplane to effectively intervene. Also contributing were systemic deficiencies in the aviation industry's selection and performance measurement practices, which failed to address the first officer's aptitude-related deficiencies and maladaptive stress response. Also contributing to the accident was the Federal Aviation Administration's failure to implement the pilot records database in a sufficiently robust and timely manner.

4. Recommendations

4.1 New Recommendations

To the Federal Aviation Administration

Inform Title 14 *Code of Federal Regulations* Part 119 certificate holders, air tour operators, fractional ownership programs, corporate flight departments, and governmental entities conducting public aircraft operations about the hiring process vulnerabilities identified in this accident, and revise Advisory Circular 120-68H, “Pilot Records Improvement Act and Pilot Records Database,” to emphasize that operators should include flight operations subject matter experts early in the records review process and ensure that significant training issues are identified and fully evaluated. (A-20-33)

Implement the pilot records database and ensure that it includes all industry records for all training started by a pilot as part of the employment process for any Title 14 *Code of Federal Regulations* Part 119 certificate holder, air tour operator, fractional ownership program, corporate flight department, or governmental entity conducting public aircraft operations regardless of the pilot’s employment status and whether the training was completed. (A-20-34)

Ensure that industry records maintained in the pilot records database are searchable by a pilot’s certificate number to enable a hiring operator to obtain all background records for a pilot reported by all previous employers. (A-20-35)

Establish a confidential voluntary data clearinghouse of deidentified pilot selection data that can be used to conduct studies useful for identifying effective, scientifically based pilot selection strategies. This program should be modeled after programs like Aviation Safety Information and Analysis Sharing and Flight Operations Quality Assurance. (A-20-36)

Issue a safety alert for operators to inform pilots and operators of Boeing 767- and 757-series airplanes about the circumstances of this accident and alert them that, due to the close proximity of the speedbrake lever to the left go-around mode switch, it is possible to inadvertently activate the go-around mode when manipulating or holding the speedbrake lever as a result of unintended contact between the hand or wrist and the go-around switch. (A-20-37)

Convene a panel of aircraft performance, human factors, and aircraft operations experts to study the benefits and risks of adapting military automatic ground collision avoidance system technology for use in civil transport-category airplanes and make public a report on the committee’s findings. (A-20-38)

4.2 Previously Issued Recommendations Reiterated and Classified in this Report

To the Federal Aviation Administration:

Require all Part 121 and 135 air carriers to obtain any notices of disapproval for flight checks for certificates and ratings for all pilot applicants and evaluate this information before making a hiring decision. (A-05-1) Classified “Open—Unacceptable Response”

Require 14 *Code of Federal Regulations* Part 121, 135, and 91K operators to document and retain electronic and/or paper records of pilot training and checking events in sufficient detail so that the carrier and its principal operations inspector can fully assess a pilot’s entire training performance. (A-10-17) Classified “Open—Unacceptable Response”

Require 14 *Code of Federal Regulations* Part 121, 135, and 91K operators to provide the training records requested in Safety Recommendation A-10-17 to hiring employers to fulfill their requirement under the Pilot Records Improvement Act. (A-10-19) Classified “Open—Unacceptable Response”

Develop a process for verifying, validating, auditing, and amending pilot training records at 14 *Code of Federal Regulations* Part 121, 135, and 91K operators to guarantee the accuracy and completeness of the records. (A-10-20) Classified “Open—Unacceptable Response”

4.3 Previously Issued Recommendations Reiterated in this Report

To the Federal Aviation Administration:

Require that all existing aircraft operated under Title 14 *Code of Federal Regulations* (*CFR*) Part 121 or 135 and currently required to have a cockpit voice recorder and a flight data recorder be retrofitted with a crash-protected cockpit image recording system compliant with Technical Standard Order TSO-C176a, “Cockpit Image Recorder Equipment,” TSO-C176a or equivalent. The cockpit image recorder should be equipped with an independent power source consistent with that required for cockpit voice recorders in 14 *CFR* 25.1457. (A-15-7)

Require that all newly manufactured aircraft operated under Title 14 *Code of Federal Regulations* (*CFR*) Part 121 or 135 and required to have a cockpit voice recorder and a flight data recorder also be equipped with a crash-protected cockpit image recording system compliant with Technical Standard Order TSO-C176a, “Cockpit Image Recorder Equipment,” or equivalent. The cockpit image recorder should be equipped with an independent power source consistent with that required for cockpit voice recorders in 14 *CFR* 25.1457. (A-15-8)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

ROBERT L. SUMWALT, III
Chairman

JENNIFER HOMENDY
Member

BRUCE LANDSBERG
Vice Chairman

MICHAEL GRAHAM
Member

THOMAS CHAPMAN
Member

Report Date: July 14, 2020

Board Member Statements

Chairman Sumwalt filed the following concurring statement on July 20, 2020; Vice Chairman Landsberg and Member Graham joined in this statement:

32 seconds. That's the amount of time that it took from Go-Around mode activation until the flight ended in tragedy.

Ten years and counting. That's the amount of time that the FAA has taken to implement a sufficiently robust Pilot Records Database (PRD), as mandated by Congress.

Nearly ten years to the date before this Atlas Air crash, another airline crash occurred under strikingly similar circumstances. In February 2009, Colgan Air flight 3407 crashed near Buffalo, NY. Like with the Atlas Air crash, the Colgan Air pilot inappropriately manipulated the elevator controls in response to a problem that he perceived – one that could have easily been handled by responding appropriately. Like with the Atlas Air crash, the airplane plummeted to the ground, shattering not only the aircraft into metal bits, but along with it, the lives of those onboard and forever changing the lives of those they left behind. Like with the Atlas Air crash, one of the pilots in that ill-fated Colgan Air cockpit had a history of piloting performance issues, some of which were concealed from the airline when he applied for employment.

In response to the Colgan Air crash, NTSB issued safety recommendations to FAA to strengthen methods for hiring airlines to ascertain a pilot applicant's background, including requiring previous employers to disclose training records and records of any previous failures. Including the Atlas and Colgan Air crashes, NTSB has investigated 11 air carrier accidents over three decades, in which pilots with a history of unsatisfactory performance had been hired by an airline where they were later involved in an accident attributed to their poor performance.

Congress took note of the NTSB recommendations issued in response to the Colgan Air crash, and crafted language into the *Airline Safety and Federal Aviation Administration Extension Act of 2010* which required FAA to establish a PRD and require that "before allowing an individual to begin service as a pilot, an air carrier shall access and evaluate … information pertaining to the individual from the pilot records database."[1] Items required to be input into the PRD and considered by hiring airlines included "training, qualifications, proficiency, or professional competence of the individual, including comments and evaluations made by a check airman designated …; any disciplinary action taken with respect to the individual that was not subsequently overturned; and any release from employment or resignation, termination, or disqualification with respect to employment."[2] Congress also appropriated $6 million per year for the next four years to help facilitate creation of the PRD – a total of $24 million.

In February 2011, FAA established an Aviation Rulemaking Committee (ARC) to gather a broad cross-section of industry stakeholders to develop recommendations on the best way to

[1] *See Airline Safety and Federal Aviation Administration Extension Act of 2010*, Section 203. PL-111-216.

[2] *Id*.

implement the PRD. Despite the ARC completing their work and issuing a report to FAA in July 2011 – just 6 months after they were tasked with developing recommendations - it wasn't until September 2015 that FAA began a phased approach to implementing the PRD.

By July 2016, Congress had become impatient with FAA's lack of progress. After all, it had been six years since they mandated that FAA create the PRD, and still no appreciable progress. In response, Congress included in the *FAA Extension, Safety, and Security Act of 2016,* a mandate that PRD be in place by April 30, 2017.

Unfortunately, April 30, 2017, came and went. Still no PRD. Meanwhile, 40 days after this Congressionally mandated deadline was missed, on June 8, 2017, the accident first officer applied for employment with Atlas Air. As this investigation uncovered, the first officer concealed his history of performance deficiencies, which deprived Atlas Air the opportunity to fully evaluate his aptitude and competency as a pilot. But, to carry it one step further, I'm convinced that had the PRD been fully implemented by the mandated deadline, it is likely that the first officer of Atlas Air 3591 would not have been hired by Atlas Air. "I can tell you right now if I had that information at the time we would not have offered him a position," Atlas Air's director of training recounted to NTSB investigators, referring to the first officer's complete training history.[3]

For these reasons, my colleagues and I voted unanimously to add this statement to the probable cause: "Also contributing to the accident was the Federal Aviation Administration's failure to implement the Pilot Records Database in a sufficiently robust and timely manner."

Sadly, we still aren't close to having a fully-implemented PRD. In March 2020, the FAA provided their first visible indication of moving forward with the PRD, when they published a Notice of Proposed Rulemaking (NPRM) to give the public a glimpse of what the proposed rule may look like. Noteworthy is that this was ten years after Congress initially mandated it, and three years after the April 2017 deadline that Congress eventually imposed.

The NPRM states that the PRD should be implemented in 2021. However, the NPRM also proposes to allow a 2-year phase-in period. This puts complete implementation somewhere around a 2023 timeframe, assuming this proposed timeline holds. If that's the case, we will finally have the PRD -- 14 years after the Colgan Air crash; 13 years after Congress mandated it; 5 years after the deadline imposed by Congress; and, four years after the tragedy of Atlas Air 3591.

As I've heard my colleague, Vice Chairman Bruce Landsberg, say, "Safety delayed is safety denied." The tragic crash of Atlas 3591 didn't need to happen – and it wouldn't have happened if the FAA had acted in a reasonable timeframe.

[3] *See* NTSB Operations Group Factual Report, Attachment 1, Atlas Air Interview Transcripts, for this accident, pp. 707-715.

Vice Chairman Landsberg filed the following concurring statement on July 16, 2020; Chairman Sumwalt and Member Graham joined in this statement:

The probable cause of the crash of the Atlas Air Boeing 767 into Trinity Bay, Texas was unfortunately predictable. A fully qualified, rated and experienced pilot forced a normally functioning aircraft into the ground. It bore remarkable similarity to Colgan 3407, a De Havilland Q-400 turboprop that crashed near Buffalo, New York in February 2009. In both cases, the aircraft was in a routine flight configuration. In both cases, due to the aircraft automation performing as designed, both pilots with thousands of hours of airline experience reacted inappropriately causing an aircraft to crash with the loss of life to all on board. Why did this happen – again? Because we didn't heed tragic and expensive lessons of the past.

After the Colgan crash, the NTSB made 46 findings, 24 new recommendations and 8 reiterated recommendations to industry and FAA on pilot selection and training. Member Tom Chapman, who currently serves on this Board, was one of the authors of the FAA temporary reauthorization in 2016 which prompted the FAA to take long overdue action on aspects of the Airline Safety Act of 2010, including the development of the Pilot Records Database. His concurring statement to this report will likely elaborate on the history. In Colgan, the Captain, who was the pilot flying, was surprised by the aircraft's automation - which was performing as designed, and he pulled the aircraft into an unrecoverable aerodynamic stall. The NTSB investigation revealed that his training history and performance prior to serving as an airline pilot and during his airline career was poor.

In this crash, the First Officer, as the pilot flying the Boeing 767, had a poor training and checking record in airline operations. He had worked for several different air carriers and in almost every instance had failed several times or did not complete training. To make matters worse, he lied on his application to Atlas, failing to list several prior employers to cover up his substandard performance.

Long before coming to NTSB, I was involved in a regional airline selection program for multiple carriers while working for a Part 143 training provider. It was a comprehensive program and operated under the premise of "trust but verify." We reviewed participants' pilot history and driving records, administered a knowledge test and conducted a thorough simulator ride in a full motion-visual turbine aircraft simulator. During the process we conducted multiple interviews and compared impressions between interviewers. Selection and course completion, if the candidates were chosen by an airline, was not guaranteed. The program was staffed by aviation professionals who knew how to read training records and ask operationally significant questions – something that was at least partially lacking in this case. It was all about performance and, to my knowledge, there was never a crash caused by any of the graduates.

The U.S. Military has a highly successful model of qualifying and managing trainees. Member Michael Graham, a retired Navy pilot and safety officer who also currently serves on this Board, noted that in his career it was sometimes necessary to inform someone that for their own safety and that of the public, they needed to find a different career field.

My colleagues on the Board seem to agree that nobody should be eliminated as they learn new skills, but at some point, there is a test, an evaluation event, or a check-ride that must be passed if minimum standards are to be maintained. The results of those check-points must be preserved and provided to future employers. Medicine, law, barbering, and real estate all have testing and standards. In professional aviation, lives are always at stake. The losses can be counted in the hundreds from a single accident. We have to get it right!

The Pilot Records Database (PRD) has been in gestation for 10 years. I can think of no good reason as to why it should have taken that long. The FAA needs to resolve this – soon. Tragic incidents overseas highlight the importance of integrity in the training and testing process. Verification is essential and properly designed electronic databases with near instant access should be accessible to anyone operating aircraft for hire.

Additionally, there may be some technical opportunities for industry. Automation mode changes, expected or otherwise, should be clear and unambiguous. We've learned that hard lesson too many times. The B767 is an older aircraft but perhaps it's possible to make some "simple" software changes to improve crew awareness. It certainly should be a priority in all new aircraft.

Underlying much of this is the ever-present economic argument. The objection seems to be that it will cost too much. That can certainly be true if systems are over engineered or if regulations are over-reaching. But with properly executed technology and a pragmatic approach to regulation there's a far better response: If you think monitoring, training or getting solid background check on a prospective pilot candidate is expensive, try having an accident.

Member Homendy filed the following concurring statement on July 24, 2020; Chairman Sumwalt and Member Graham joined in this statement:

The crash of Atlas Air Flight 3591 tragically took the lives of three pilots. My thoughts continue to be with the families and friends of those that lost loved ones in this tragedy. I do believe that the findings and safety recommendations resulting from this investigation, if swiftly acted upon, will go a long way toward preventing recurrence of a similar accident.

In discussing the draft report with staff prior to the board meeting and reviewing the evidence in the docket, I debated on offering an amendment to the probable cause to focus more on Atlas Air's failures to fully evaluate the Pilot Records Information Act (PRIA) documentation on the first officer (FO) and to fully assess his numerous training deficiencies at Atlas prior to beginning service.

My initial concern was that our probable cause identified "systemic deficiencies in the aviation industry's selection and performance measurement practices" as contributing to the accident, and I questioned whether the entire aviation industry should shoulder responsibility for this crash. However, as stated in the final report, over the past 32 years the NTSB has repeatedly highlighted the hazards posed by pilots with a history of performance difficulties by recommending that the aviation industry, and regulators, implement measures to ensure more thorough examination of a pilot applicant's employment history and closer monitoring of pilots who experience problems during training. Those repeated warnings to industry stemmed from numerous crashes we investigated and, clearly, were ignored so it's absolutely appropriate that our probable cause focuses on the systemic deficiencies of the entire aviation industry.

That said, this report, the probable cause, our findings, and our recommendations should never be viewed as giving Atlas a pass. Within the PRIA paperwork provided to Atlas, there were indications of the FO's training difficulties at Mesa Airlines. Atlas Air missed those weaknesses in their review. Atlas Air relied heavily on a designated agent to collect and review the applicant's previous employment and training history. While the designated agent stated there were no deficiencies, the corresponding paperwork listed the FO's failure to upgrade to Captain at Mesa nine times. When Atlas was made aware of his failure to upgrade by our investigators, the Director of Human Resources and the Director of Training stated that, in hindsight, it would have been a "red flag" and warranted further review.

Ultimately, it's not the designated agent's responsibility to thoroughly evaluate the paperwork. It's the operator's responsibility. If Atlas Air had performed the detailed review of the records they did receive, that may have provided Atlas with additional insight into the FO and enabled them to fully assess the deficiencies he displayed during initial training. While the Proficiency Watch Program (PWP) at Atlas Air was changed from a focus on single failure events, the FO demonstrated a number of difficulties that when reviewed in context of his previous training history at past employers could have given the fleet captain a better understanding of his history. Rather than just increase the number of operating experience hours the FO needed, he may have been referred to the training review board and possible inclusion in the PWP, where he would've been monitored.

Weaknesses in both PRIA and Atlas Air's PWP were contributing factors to the FO being able to secure employment, complete his training, and fly the line without receiving any special scrutiny after he obtained his type rating in the B767. Following the accident, Atlas Air should address deficiencies in their PWP and all other airlines should evaluate their programs to address similar weaknesses.

I hope Atlas Air and others in the industry will learn from this accident and make appropriate changes to their hiring process and training programs, with the goal of preventing recurrence of a similar accident. And while the safety recommendations we made to the Federal Aviation Administration (FAA) will help improve safety, the industry shouldn't wait for the FAA to act on those recommendations. There are steps they can take now to more fully evaluate who they are putting into the cockpit of their aircraft.

Member Graham filed the following concurring statement on July 20, 2020; Chairman Sumwalt and Vice Chairman Landsberg joined in this statement:

I concur and join the Board's unanimous adoption of the Probable Cause, Findings, and Recommendations.

32 seconds after the inadvertent activation of the go-around switch a perfectly good aircraft was flown into a marsh and the public and industry alike were left stunned wondering how this could have happened. The Board's adopted Probable Cause cites, as contributing factors, the captain's failure to assume positive control of the aircraft and the first officer's aptitude-related deficiencies and maladaptive response.

The captain's actions to recover the aircraft failed without a positive transfer of controls. As the FO pushed the column forward causing a rapid descent, the Captain pulled the column back splitting the elevators. In an unexpected, high stress event the Captain and FO opposed each other for control of the aircraft. One pilot must fly the airplane, but ultimately the captain has full responsibility and final authority for its safe operation. The Captain failed to act on this responsibility contrary to standard operating procedures and his prior training and experience. By not communicating a positive transfer of control with "I have control" the Captain pulling back on the column was futile.

As the pilot flying Atlas Air Flight 3591, the FO fatally demonstrated what his previous employers already knew: he lacked the basic airmanship skills required to perform as a pilot much less an airline transport pilot. His training performance, deficient skills, and inappropriate responses at multiple carriers confirmed this. At some point one of these instructors, training review boards, or companies should have pulled him from the cockpit. As a former Naval instructor pilot and training officer of a Fleet Replacement Squadron, I had the unpleasant job of informing a few pilots their career was over because of a lack of airmanship skills, unsafe acts, poor judgement, or a constant lack of situational awareness. Each time it pained me, but it was required to protect the pilot and the operation. The FO demonstrated a lack of basic airmanship skills by failing to complete initial training at CommutAir and AirWisconsin, registering three failures at Trans States, failing an upgrade to Captain at Mesa where he was referred to as a "train wreck" by the training manager, and experiencing four training failures at Atlas in the first three months. Each operator had a chance to stop the cycle by recommending an alternate career for the FO.

This accident should be a wake-up call to the industry. An operation is only as strong as its weakest player. It is time for the industry to reevaluate its substandard pilots with continued training and performance deficiencies as well as those who cannot upgrade. Hard questions should be asked and difficult decisions must be made. Can these pilots improve their performance with additional training, or should they be pulled from the cockpit because they put themselves, the operation, and the public at risk? What happened to Atlas Air Flight 3591 on February 23, 2019 was tragic, but this accident could have occurred at any one of the FO's previous employers.

Member Chapman filed the following concurring statement on July 17, 2020; Chairman Sumwalt, Vice Chairman Landsberg, and Member Graham joined in this statement:

I concur and join in the Board's unanimous adoption of the accident report.

FAA's delay in implementing the Pilot Records Database is of particular concern to all of us, and to me, personally. During my six-year tenure on the staff of the Senate Aviation Subcommittee, this is an issue to which my colleagues and I devoted significant attention. I believe sharp scrutiny of FAA's inaction is warranted.

The Pilot Records Database was mandated by the Airline Safety and Federal Aviation Administration Extension Act of 2010. That legislation became law ten years ago, in the wake of the February 2009 crash of Colgan Air Flight 3407. Six years after passage of the original legislation, frustration with FAA's slow pace resulted in Congress imposing an explicit deadline for implementation of the Pilot Records Database. A deadline of April 30, 2017 was imposed by Section 2101 of the FAA Extension, Safety, and Security Act of 2016.

FAA has missed that April 2017 deadline by more than three years and only recently published the Notice of Proposed Rulemaking relating to implementation of the database. The Atlas Air accident occurred in February of 2019, almost 2 years after the missed deadline. Another year passed before FAA finally issued the NPRM.

So here we are, a decade after Congress directed FAA to act. And we are still waiting for the FAA to fulfill the mandate and make this important tool available, ensuring airlines will have information vital to their ability to evaluate and screen prospective pilots.

Our investigation of the Atlas Air tragedy indicates the first officer's incomplete disclosure of information about his employment background was intended to conceal his history of weak performance. If the Pilot Records Database had been in place and implemented as intended, it is likely Atlas Air would have had a better opportunity to fully evaluate the first officer's proficiency and employment history.

FAA's primary mission is the safety of air commerce. It is an agency with 46,000 employees and an annual budget of $18 billion. These are ample resources to fulfill its safety mission. A decade is ample time for FAA to have completed work on the Pilot Records Database. Doing so is a safety imperative, as plainly demonstrated by the sad facts of this accident.

5. Appendixes

Appendix A: Investigation

The National Transportation Safety Board (NTSB) was notified of this accident on February 23, 2019, and members of the investigative team arrived on scene later that day. Chairman Robert L. Sumwalt accompanied the team.

Investigative groups were formed to evaluate operational factors and human performance, structures, systems, powerplants, maintenance records, and air traffic control services and to perform a sound spectrum study on the audio recording from the cockpit voice recorder (CVR). Also, specialists were assigned to evaluate meteorology, CVR data, flight data recorder data, and to perform an airplane performance study.

The Federal Aviation Administration, Atlas Air Inc., The Boeing Company, GE Aviation, Rockwell Collins Inc., the National Air Traffic Controllers Association, and the International Brotherhood of Teamsters were parties to the investigation.

Appendix B: Consolidated Recommendation Information

Title 49 *United States Code* (*USC*) 1117(b) requires the following information on the recommendations in this report.

For each recommendation—

(1) a brief summary of the Board's collection and analysis of the specific accident investigation information most relevant to the recommendation;

(2) a description of the Board's use of external information, including studies, reports, and experts, other than the findings of a specific accident investigation, if any were used to inform or support the recommendation, including a brief summary of the specific safety benefits and other effects identified by each study, report, or expert; and

(3) a brief summary of any examples of actions taken by regulated entities before the publication of the safety recommendation, to the extent such actions are known to the Board, that were consistent with the recommendation.

To the Federal Aviation Administration

Inform Title 14 *Code of Federal Regulations* Part 119 certificate holders, air tour operators, fractional ownership programs, corporate flight departments, and governmental entities conducting public aircraft operations about the hiring process vulnerabilities identified in this accident, and revise Advisory Circular 120-68H, "Pilot Records Improvement Act and Pilot Records Database," to emphasize that operators should include flight operations subject matter experts early in the records review process and ensure that significant training issues are identified and fully evaluated. (A-20-33)

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4.2 Atlas' Review of Available Training Records. Information supporting (b)(1) can be found on pages 46-47; (b)(2) is not applicable; and (b)(3) can be found on pages 46-47.

Implement the pilot records database and ensure that it includes all industry records for all training started by a pilot as part of the employment process for any Title 14 *Code of Federal Regulations* Part 119 certificate holder, air tour operator, fractional ownership program, corporate flight department, or governmental entity conducting public aircraft operations regardless of the pilot's employment status and whether the training was completed. (A-20-34)

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.5.1 Limitations of the Retrieval Process for Background Records. Information supporting (b)(1) can be found on pages 49-51; (b)(2) can be found on pages 49-50; and (b)(3) can be found on pages 49-50.

> Ensure that industry records maintained in the pilot records database are searchable by a pilot's certificate number to enable a hiring operator to obtain all background records for a pilot reported by all previous employers. (A-20-35)

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.5.1 Limitations of the Retrieval Process for Background Records. Information supporting (b)(1) can be found on pages 49-51; (b)(2) is not applicable; and (b)(3) can be found on page 49-50.

> Establish a confidential voluntary data clearinghouse of deidentified pilot selection data that can be used to conduct studies useful for identifying effective, scientifically based pilot selection strategies. This program should be modeled after programs like Aviation Safety Information and Analysis Sharing and Flight Operations Quality Assurance. (A-20-36)

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.5.2 Need for Improved Pilot Selection and Performance Measurement Methods. Information supporting (b)(1) can be found on pages 51-53; (b)(2) is not applicable; and (b)(3) can be found on pages 51-53.

> Issue a safety alert for operators to inform pilots and operators of Boeing 767- and 757-series airplanes about the circumstances of this accident and alert them that, due to the close proximity of the speedbrake lever to the left go-around mode switch, it is possible to inadvertently activate the go-around mode when manipulating or holding the speedbrake lever as a result of unintended contact between the hand or wrist and the go-around switch. (A-20-37)

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.6.1 Awareness Information for Pilots of Boeing 767- and 757-Series Airplanes. Information supporting (b)(1) can be found on pages 53-54; (b)(2) is not applicable; and (b)(3) can be found on pages 53-54.

> Convene a panel of aircraft performance, human factors, and aircraft operations experts to study the benefits and risks of adapting military automatic ground collision avoidance system for use in civil transport-category airplanes and make public a report on the committee's findings. (A-20-38)

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.6.2 Adaptations for Automatic Ground Collision Avoidance Technology. Information supporting (b)(1) can be found on pages 54-56; (b)(2) is not applicable; and (b)(3) can be found on pages 54-56.

Appendix C: Safety Recommendations Related to Pilot Records and Remedial Training

	Number	Classification	Date Closed	Recommendation
Closed Recommendations				
1	**A-88-141**	Closed—Unacceptable Action/Superseded	11/21/1990	**To the Federal Aviation Administration:** Require commercial operators to conduct substantive background checks of pilot applicants, which include verification of personal flight records and examination of training, performance, and disciplinary records of previous employers and Federal Aviation Administration safety and enforcement records. (Superseded by A-90-141)
2	**A-90-141**	Closed—Unacceptable Action	10/20/1992	**To the Federal Aviation Administration:** Require commercial operators to conduct substantive background checks of pilot applicants, which include verification of personal flight records and examination of training, performance, and disciplinary and other records of previous employers, the Federal Aviation Administration safety and enforcement records, and the National Drivers Register. (Supersedes A-88-141)
3	**A-94-24**	Closed—Unacceptable Action/Superseded	1/23/1996	**To the Federal Aviation Administration:** Review the pilot training recordkeeping systems of airlines operated under FAR Parts 121 and 135 to determine the quality of information contained therein, and require the airlines to maintain appropriate information on the quality of pilot performance in training and checking programs. (Superseded by A-95-115 through A-95-119)*
4	**A-95-117**	Closed—Acceptable Alternate Action	6/2/1997	**To the Federal Aviation Administration:** Require all airlines operating under 14 *CFR* Parts 121 and 135 and independent facilities that train pilots for the airlines to provide the FAA, for incorporation into a storage and retrieval system, pertinent standardized information on the quality of pilot performance in activities that assess skills, abilities, knowledge, and judgment during training, check flights, initial operating experience, and line checks. (Supersedes A-94-24)
5	**A-95-118**	Closed—Acceptable Alternate Action	6/2/1997	**To the Federal Aviation Administration:** Maintain a storage and retrieval system that contains pertinent standardized information on the quality of 14 *CFR* Parts 121 and 135 airline pilot performance during training in activities that assess skills, abilities, knowledge, and judgment during training, check flights, initial operating experience, and line checks. (Supersedes A-94-24)

* Safety Recommendation A-95-115 was issued to Air Transport International and Safety Recommendation A-95-116 was reconsidered.

	Number	Classification	Date Closed	Recommendation
6	**A-95-119**	Closed—Acceptable Alternate Action	6/2/1997	**To the Federal Aviation Administration:** Require all airlines operating under 14 *CFR* Parts 121 and 135 to obtain information, from the FAA's storage and retrieval system that contains pertinent standardized pilot training and performance information, for the purpose of evaluating applicants for pilot positions during the pilot selection and hiring process. The system should have appropriate privacy protections, should require the permission of the applicant before release of the information, and should provide for sufficient access to the records by an applicant to ensure accuracy of the records. (Supersedes A-94-24)
7	**A-05-14**	Closed—Acceptable Action	3/18/2014	**To the Federal Aviation Administration:** Require all 14 *Code of Federal Regulations* Part 121 air carrier operators to establish programs for flight crewmembers who have demonstrated performance deficiencies or experienced failures in the training environment that would require a review of their whole performance history at the company and administer additional oversight and training to ensure that performance deficiencies are addressed and corrected.
				Open Recommendations
8	**A-05-1**	Open—Unacceptable Response**	N/A	**To the Federal Aviation Administration:** Require all Part 121 and 135 air carriers to obtain any notices of disapproval for flight checks for certificates and ratings for all pilot applicants and evaluate this information before making a hiring decision.
9	**A-10-17**	Open—Unacceptable Response**	N/A	**To the Federal Aviation Administration:** Require 14 *Code of Federal Regulations* Part 121, 135, and 91K operators to document and retain electronic and/or paper records of pilot training and checking events in sufficient detail so that the carrier and its principal operations inspector can fully assess a pilot's entire training performance.
10	**A-10-18**	Open—Acceptable Response	N/A	**To the Federal Aviation Administration:** Require 14 *Code of Federal Regulations* Part 121, 135, and 91K operators to include the training records requested in Safety Recommendation A-10-17 as part of the remedial training program requested in Safety Recommendation A-05-14.
11	**A-10-19**	Open—Unacceptable Response**	N/A	**To the Federal Aviation Administration:** Require 14 *Code of Federal Regulations* Part 121, 135, and 91K operators to provide the training records requested in Safety Recommendation A-10-17 to hiring employers to fulfill their requirement under the Pilot Records Improvement Act.

** This classification was assigned in this report.

	Number	Classification	Date Closed	Recommendation
12	**A-10-20**	Open—Unacceptable Response**	N/A	**To the Federal Aviation Administration:** Develop a process for verifying, validating, auditing, and amending pilot training records at 14 *Code of Federal Regulations* Part 121, 135, and 91K operators to guarantee the accuracy and completeness of the records.
13	**A-19-7**	Open—Acceptable Response	N/A	**To the Federal Aviation Administration:** Require all Title 14 *Code of Federal Regulations* Part 135 operators to establish programs for flight crewmembers who have demonstrated performance deficiencies or experienced failures during training and administer additional oversight and training to address and correct performance deficiencies.

** This classification was assigned in this report.

Appendix D: Cockpit Voice Recorder Transcript

Transcript of a Honeywell 6022 solid-state cockpit voice recorder, serial number 61829, installed on an Atlas Air Cargo Boeing 767-375BCF (N1217A), which crashed in Trinity Bay, Texas.

LEGEND

CAM	Cockpit area microphone voice or sound source
APR	Radio transmission from Houston approach controller
CTR	Radio transmission from Houston center controller
HOT	Flight crew audio panel voice or sound source
RDO	Radio transmissions from N1217A
-1	Voice identified as the captain.
-2	Voice identified as the first officer.
-3	Voice identified as the jumpseater
-?	Voice unidentified
*****	Unintelligible word
#	Expletive
@	Non-pertinent word
( )	Questionable insertion
[ ]	Editorial insertion

Note 1: Times are expressed in CST.

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. Typically, this is used in place of a person's name which has been redacted.

Note 5: An en dash (–) denotes when a speaker was cut off by a noise or another speaker.

Intra-Aircraft Communication		Over-the-Air Communications	
		11:57:59.1 **RDO-1**	Houston good afternoon Giant thirty-five ninety-one heavy four zero zero.
		11:58:03.6 **CTR**	Giant thirty-five ninety-one Houston Center good – uh good afternoon sir- expect light chop.
		11:58:09.0 **RDO-1**	roger yeah we've been pickin' up a little bit- just intermittent.
		11:58:11.8 **CTR**	okie doke.
11:58:12.6 **CAM-1**	alright- um...		
		11:58:15.2 **CTR**	Giant thirty-five ninety-one advise when you're ready.
		11:58:24.3 **RDO-1**	okay uh Giant thirty-five ninety-one we're ready.
		11:58:27.5 **CTR**	Giant thirty-five ninety-one after uh GIRLY after GIRLY cleared to the terminal via LINKK ONE arrival LINKK ONE maintain flight level four zero zero.
		11:58:35.8 **RDO-1**	alright after GIRLY LINKK ONE and we'll stay four zero zero thanks Giant thirty-five ninety-one.
11:58:45.2 **CAM**	[Sound similar to lavatory door lock being operated.]		

Intra-Aircraft Communication		Over-the-Air Communications	
		11:58:53.8 **CTR**	* Giant thirty-five ninety-one read back broke up a little bit uh GIRLY LINKK ONE arrival four zero zero. got it?
		11:58:58.9 **RDO-1**	yes sir uh GIRLY LINKK ONE arrival and four zero zero thirty-five ninety-one.
		11:59:03.8 **CTR**	great. thanks.
11:59:07.6 **CAM-2**	okay.		
11:59:28.3 **CAM-1**	uh there's GIRLY.		
11:59:33.2 **CAM-1**	okay.		
11:59:39.7 **CAM-1**	alright LINKK ONE.		
11:59:41.0 **CAM-2**	yeah.		
11:59:42.3 **CAM-2**	(so) go ahead (go ahead) put that in the box LINKK ONE arrival.		
11:59:47.2 **CAM-1**	two six right?		
11:59:47.8 **CAM-2**	two six right.		
11:59:48.8 **CAM-1**	I mean that's what I'm thinkin'.		

Intra-Aircraft Communication		Over-the-Air Communications
11:59:49.4 **CAM-2**	ummm- using flap twenty five. autobrakes (three/basically)–	
11:59:53.6 **CAM-1**	GIRLY.	
11:59:54.3 **CAM-2**	yup.	
11:59:55.8 **CAM-1**	and I'm gunna leave that by you probably do ZAPPO but I'll leave it like it is for now.	
11:59:59.0 **CAM-2**	okayyy.	
11:59:59.8 **CAM-1**	so let's go to legs.	
12:00:04.7 **CAM-1**	BBQUE.	
12:00:08.6 **CAM-1**	if you watch yours I'll - I'll read 'em out.	
12:00:10.0 **CAM-2**	okay.	
12:00:10.5 **CAM-1**	alright at BBQUE at uh speed two eighty. two ten or below.	
12:00:15.2 **CAM-2**	yes.	
12:00:15.7 **CAM-1**	LINKK at two fifty between twelve and fifteen.	
12:00:18.3 **CAM-2**	roger.	

Intra-Aircraft Communication		Over-the-Air Communications
12:00:18.9		
CAM-1	GILLL at eight between eight and ten and two forty.	
12:00:21.8		
CAM-2	yeap.	
12:00:22.5		
CAM-2	then GARRR.	
12:00:23.7		
CAM-1	and then vectors.	
12:00:25.0		
CAM-2	* six thousand's the bottom altitude.	
12:00:26.7		
CAM-1	alright.	
12:00:28.8		
CAM-1	confirm?	
12:00:29.6		
CAM-2	execute.	
12:00:31.8		
CAM-1	alright autobrakes what?	
12:00:33.0		
CAM-2	(uh/auto) two.	
12:00:35.8		
CAM-1	flaps twenty-five. okay.	
12:00:36.8		
CAM-2	*.	
12:00:37.1		
CAM-1	let me get the new ATIS and I'll get us set up.	

Intra-Aircraft Communication		Over-the-Air Communications	
12:00:47.6 **CAM-2**	you can put also put uh- two seven in also.		
		12:00:53.6 **CTR**	attention all aircraft hazardous information Houston Center weather advisory two zero five for Mississippi Alabama region available on HIWAS Flightwatch flight * *-.
12:01:29.2 **CAM-?**	[Sound similar to yawn.]		
12:01:42.0 **CAM-2**	*.		
12:01:44.1 **CAM-1**	what's that?		
12:01:45.2 **CAM-2**	just yawning.		
12:01:49.2 **CAM-1**	would you grab that uh-		
12:01:50.7 **CAM-2**	(huh/oh)?		
12:01:52.1 **CAM-1**	ATIS please.		
12:01:57.0 **CAM-1**	thank ya sirrr.		
12:01:59.9 **CAM-1**	alright two thirty fourrr.		
12:02:06.9 **CAM-1**	two eleven eight. aaand eighteen four.		

Intra-Aircraft Communication		Over-the-Air Communications
12:02:19.3 **CAM-1**	two- zero two thirty four. two three zero point two.	
12:02:27.7 **CAM-1**	double bug one twenty six.	
12:02:31.4 **CAM-1**	uhhh and so on ref speed-	
12:02:37.9 **CAM-1**	you wanna add twenty to that? well let's see what's it doin' now?	
12:02:40.3 **CAM-2**	that's where the winds are first.	
12:02:42.6 **CAM-1**	and now it's just three two- three two zero at fourteen.	
12:02:45.8 **CAM-2**	oh okay not that bad.	
12:02:48.8 **CAM-2**	winds are-	
12:02:50.6 **CAM-2**	three two zero at fourteen so-	
12:02:52.7 **CAM-2**	sixty two two oh [zero] two. are the flaps...	
12:02:55.7 **CAM-1**	huh?	
12:02:57.6 **CAM-2**	(on the five- plus five-) add five to that.	
12:03:00.8 **CAM-2**	so like uh one.	

Intra-Aircraft Communication		Over-the-Air Communications
12:03:01.6 **CAM-1**	so you want me to put it on here do you wanna put it?	
12:03:03.4 **CAM-2**	(let's/plus twelve) let's put it on here.	
12:03:04.7 **CAM-1**	okay so what we got? one twenty six?	
12:03:07.2 **CAM-2**	one twenty six.	
12:03:07.7 **CAM-1**	(plan) one thirty two or something like that.	
12:03:09.5 **CAM-2**	plan one thirty two.	
12:03:11.6 **CAM-2**	let's just call it one thirty five.	
12:03:13.2 **CAM-2**	one–	
12:03:13.5 **CAM-1**	one thirty five.	
12:03:13.7 **CAM-2**	one thirty five–	
12:03:14.1 **CAM-2**	call it (like that).	
12:03:15.3 **CAM-1**	I just put this that's my reminder.	
12:03:16.7 **CAM-2**	ohh okay * *-	

Intra-Aircraft Communication		Over-the-Air Communications
12:03:17.4 **CAM-1**	(to) set that for ya.	
12:03:18.0 **CAM-2**	(okay).	
12:03:18.8 **CAM-1**	uhhh- okay.	
12:03:21.0 **CAM-1**	let me do this now.	
12:04:04.2 **CAM-1**	ahhh sooo- put two seven instead of two six right.	
12:04:11.8 **CAM-2**	* two six right and two seven (I believe) one of those two. what'd you think?	
12:04:16.8 **CAM-1**	what I think it'll either be the left side- the left or the bottom- I think.	
12:04:23.0 **CAM-2**	* (left/land) (and)-	
12:04:26.6 **CAM-1**	two six left or two seven.	
12:04:28.2 **CAM-2**	yeah.	
12:04:28.6 **CAM-1**	I'm hoping they'll get tho-those two- the top two. they'll probably give it to us- we'll ask for it.	
12:04:32.6 **CAM-2**	yup. okay.	

Intra-Aircraft Communication		Over-the-Air Communications
12:04:33.6 **CAM-1**	if we need to I'll get- I'll get a different one.	
12:04:36.2 **CAM-2**	that sounds good.	
12:04:38.7 **CAM-1**	I mean two seven's–	
12:04:39.6 **CAM-2**	I agree I agree.	
12:04:40.6 **CAM-1**	two seven’s even longer so we'll be good.	
12:04:42.1 **CAM-2**	* * *.	
12:04:44.6 **CAM-2**	yes.	
12:04:46.0 **CAM-2**	yeah those two close to where we are.	
12:05:11.8 **CAM**	[Chime. Sound similar to ACARS information arrival for landing data.]	
12:06:28.3 **CAM-1**	like it?	
12:06:28.9 **CAM-2**	* (let's see / *).	
12:06:32.8 **CAM-1**	let's see-	

Intra-Aircraft Communication		Over-the-Air Communications	
12:06:43.0 **CAM-1**	which one (do you thin...)- I mean if they give me a choice- I'd take two six right 'cause we- we get–		
		12:06:48.2 **CTR**	Giant thirty five ninety one traffic- descend and maintain flight level three five zero.
		12:06:52.2 **RDO-1**	descend three five zero Giant thirty five ninety one.
12:06:54.5 **CAM-2**	three five zero.		
12:06:54.9 **CAM-1**	three five zero set.		
12:06:56.1 **CAM-2**	yeah the last time I saw it was two six right and (what they) give us.		
12:06:59.0 **CAM-1**	so I'll set ya up with that- I'll change it-		
12:07:00.2 **CAM-2**	two six right.		
12:07:01.2 **CAM-2**	I agree.		
		12:07:24.9 **CTR**	Giant thirty five ninety one contact Houston Center one three four point niner two so long.
		12:07:29.2 **RDO-1**	thirty four ninety two have a good weekend

Intra-Aircraft Communication		Over-the-Air Communications	
		12:07:35.3 **RDO-1**	Houston good afternoon- Giant thirty five ninety one is uhhh four zero zero descending uh thirty five- three five zero. thanks.
12:07:40.7 **CAM-2**	set.		
12:07:45.8 **CAM-2**	* * (set). [FO speaking under his breath.]		
12:07:47.3 **CAM-?**	(ugh/yeah).		
		12:07:48.5 **CTR**	who made that last call?
		12:07:49.9 **RDO-1**	yes sir Giant thirty five ninety one is uh three nine zero descending three five zero.
12:07:57.1 **CAM-1**	(let's get the)–		
		12:07:57.7 **CTR**	Giant uhhh [Sound similar to radio interference.] thirty five ninety one roger- descend and maintain flight level three four zero. [Sound similar to radio interference.]
12:07:57.7 **CAM-2**	doin' two eighty in the descent–		
		12:08:04.1 **RDO-1**	descend three four zero Giant thirty five ninety one.
12:08:06.8 **CAM-1**	thirty-four set.		

Intra-Aircraft Communication		Over-the-Air Communications
12:08:07.3 **CAM-2**	think we're good.	
12:08:07.8 **CAM-1**	what do you–	
12:08:07.9 **CAM-2**	what'd he- what'd he said two eight zero?	
12:08:10.1 **CAM-1**	yeah it's fine.	
12:08:15.3 **CAM-1**	damn.	
12:08:17.0 **CAM-1**	alllright. eleven fifty-five-	
12:08:19.5 **CAM-2**	okay so-	
12:08:20.2 **CAM-1**	two sixty seven.	
12:08:25.6 **CAM-2**	okay.	
12:08:26.6 **CAM-1**	uhhh let's see. minimums.	
12:08:28.8 **CAM-2**	minimums are gunna be three- four ninety-six I guess.	
12:08:32.2 **CAM-2**	three ninety-six.	
12:08:33.7 **CAM-1**	three ninety-six- four hundred.	

Intra-Aircraft Communication		Over-the-Air Communications
12:08:30.4 **HOT-2**	four ninety-six I guess.	
12:08:32.4 **HOT-1**	three ninety-six.	
12:08:32.5 **HOT-2**	oh three ninety-six.	
12:08:33.7 **HOT-1**	three ninety-six four hundred.	
12:08:35.5 **HOT-1**	‘bout four hundred’s close enough.	
12:08:36.6 **HOT-2**	'kay four hundred is close.	
12:08:40.2 **HOT-2**	speed.	
12:08:43.0 **HOT-2**	(gunna) be small (seven three).	
12:08:50.5 **HOT-2**	confirm.	
12:08:51.2 **HOT-1**	execute.	
12:08:53.3 **HOT-2**	okay.	
12:08:54.2 **HOT-1**	# man I'm bleeding.	
12:08:55.6 **HOT-2**	(is it) 'cause the clouds?	

Intra-Aircraft Communication		Over-the-Air Communications
12:08:57.2 **HOT-1**	yeah.	
12:08:58.6 **HOT-1**	I'm bleeding.	
12:08:58.6 **HOT-2**	('turb) ohhh.	
12:09:00.4 **HOT-1**	I think my - I don't know which one it is but I hit my head every time I get out and I've got like a permanent scar now.	
12:09:05.5 **HOT-2**	ohhkay.	
12:09:08.3 **HOT-2**	back to two eighty- confirmed.	
12:09:10.0 **CAM-1**	#.	
12:09:16.2 **HOT-1**	I (don't/no) like-a da bumps. [Spoken in an accent.]	
12:09:20.8 **CAM**	[Sound of click.]	
12:09:33.3 **HOT-1**	[Sound of groan/yawn.]	
12:09:41.3 **HOT-2**	okay - I'm gunna giva ya controls when you're ready.	
12:09:45.2 **HOT-1**	alright one second.	

Intra-Aircraft Communication		Over-the-Air Communications
12:09:53.9 **CAM**	[Sound of click.]	
12:09:58.4 **HOT-1**	alright I got controls.	
12:09:59.4 **HOT-2**	alright your controls LNAV VNAV center autopilot command. we're level - we're thousand feet to go- a thousand to level.	
12:10:03.9 **HOT-1**	thousand level off.	
12:10:05.6 **HOT-2**	your controls.	
12:10:15.6 **HOT-1**	come on baby.	
12:10:22.4 **HOT-2**	it's always * * *.	
12:10:22.4 **HOT-1**	let's go.	
12:10:26.3 **HOT-2**	sooo.	
12:10:27.7 **HOT-1**	why is it not descending?	
12:10:42.3 **HOT-1**	ohhh VNAV. [Sound of chuckle.]	
12:10:43.6 **HOT-2**	okay.	

Intra-Aircraft Communication		Over-the-Air Communications
12:10:44.3 **HOT-1**	there we go.	
12:10:46.3 **HOT-2**	ohhh 'kayyy.	
12:10:50.6 **HOT-2**	so we have - (it's listed as) GIRLY BBQUE at two eighty flight level two ten. twenty-one thousand feet LINKS [LINKK] uh two fifty between fifteen and twelve thousand feet. then we have GILLL two forty um at or above ten thousand and eight - and then two ten at six thousand- at uhh– GARRR (I'm sorry)- two ten at seven thousand. so seven thousand will be the bottom altitude.	
12:11:30.4 **HOT-1**	seven’s the bottom?	
12:11:31.4 **HOT-2**	yes.	
12:11:32.1 **HOT-1**	okay.	
12:11:32.2 **HOT-2**	(so) let's confirm that- two six left.	
12:11:36.9 **HOT-2**	two huh two seven and six thousand.	
12:11:39.2 **HOT-1**	yeah 'cause we're goin' to GARRR.	
12:11:40.3 **HOT-2**	yeah. and two ten. okay?	

Intra-Aircraft Communication		Over-the-Air Communications
12:11:48.8 **HOT-1**	well unless they change it we're goin' to two seven- oh we're changin' it in here then-	
12:11:51.8 **HOT-2**	okay.	
12:11:52.5 **HOT-1**	and then it'll be six- but they'll- they'll let us know.	
12:11:53.8 **HOT-2**	then it'll be six [two six]. yes.	
12:11:55.9 **HOT-2**	sooo we are planning I-L-S runway two-six right- into Houston seventy-one dash six is what I have. eleven point five five and two sixty-seven on the final approach course. we have OWELL and uhhh- OWELL- uhh two thousand feet- and the published gunna be- four- uhhh three ninety-six- we have four hundred set. we have uh a touchdown of ninety-six and an M-S-A of twenty-four hundred in the west side thirty one hundred east side.	
12:12:29.2 **HOT-1**	okay.	
12:12:29.4 **HOT-2**	if we go missed- in the event we have to go missed- it's gunna be climbing to six hundred feet- six hundred feet- um- outbound- up to right turn three thousand feet. and and on the three forty four.	
12:13:02.7 **HOT-2**	three forty-four radial to PEPBI intersection which I saw that there- PEPBI intersection and hold three thousand.	

Intra-Aircraft Communication		Over-the-Air Communications
12:13:11.2 **HOT-2**	or directed by A-T-C. the transition is eighteen thousand feet. we have the requirements-	
12:13:15.7 **HOT-1**	yeah I can't hear ya man.	
12:13:17.7 **HOT-2**	huh?	
12:13:18.2 **HOT-1**	it's hard to hear ya.	
12:13:18.7 **HOT-2**	ohh the transition is-	
12:13:19.8 **HOT-1**	ya talkin'- ya talkin' to the front of the plane so.	
12:13:21.7 **HOT-2**	ahh okay transition is eighteen thousand feet so we have that is all done. ummm.	
12:13:29.3 **HOT-2**	ahh we have A-L-S-F lighting system on this one- no PAPIs on the uhh-	
12:13:33.6 **HOT-2**	(we have * captain) * * (we're adding a hundred to (our) mins three ninety-six. we have all the requirements we have more than enough visibility to shoot this approach. um- upon landing- two six right- come back down. foxtrot alpha- foxtrot alpha foxtrox- oh #-	
12:13:55.8 **HOT-2**	foxtrot alpha- foxtrot hotel- foxtrot echo probably (delta/down) this way.	

Intra-Aircraft Communication		Over-the-Air Communications	
12:14:00.1 **HOT-2**	sooo-		
12:14:00.7 **HOT-1**	perfect.		
12:14:01.4 **HOT-2**	yeap.		
12:14:02.0 **HOT-2**	and umm as far as my uhh technique in landing this plane- umm a thousand feet- I'll take the autopilot off- roughly. at five hundred feet or below ill probably take the auto throttles off when I come in I pretty much keep my power in until around thirty feet or so- and that's when I start leveling off- then coming back slowly on the power so- um you can expect that. um other than that- if we have to go missed it's gunna be go around- flaps twenty- positive climb. go gear up. um at a thousand feet eh you know we go uh speed- select speed.		
12:14:36.4 **HOT-1**	flight level change.		
		12:14:36.9 **CTR**	Giant thirty-five ninety-one contact Houston Center one three three point eight.
12:14:37.0 **HOT-2**	flight level change set speed.		
		12:14:41.3 **RDO-1**	one three three decimal eight Giant eh thirty five ninety one.
12:14:45.9 **HOT-2**	I'm staying at flaps five.		

Intra-Aircraft Communication		Over-the-Air Communications
12:14:47.4 **HOT-1**	no questions. good brief.	
12:14:48.7 **HOT-2**	okay.	
12:14:51.2 **HOT-1**	alright. uhhh so. three four zero center autopilot command your controls.	
12:14:55.9 **HOT-2**	my controls (let's) go recall review descent checklist.	
12:15:00.9 **HOT-1**	no items.	
12:15:01.8 **HOT-2**	okay.	
12:15:04.3 **HOT-1**	alright. pressurization.	
12:15:07.0 **HOT-2**	uhh it's set.	
12:15:08.5 **HOT-1**	it isss set for Houston. I'll do the crossfeed real quick.	
12:15:13.0 **HOT-2**	okay.	
12:15:17.2 **HOT-1**	cross- alright crossfeed's been checked uhh recall's been checked. autobrakes two is set. landing data V ref of one twenty-six- we'll go one thirty-five uhh on our speed all the way down. and uh minimums are four hundred feet set and approach brief complete descent check complete.	

Intra-Aircraft Communication		Over-the-Air Communications	
12:15:32.0 **HOT-2**	(roger/all done.) checklist complete.		
		12:15:32.6 **RDO-1**	Houston. good afternoon. Giant thirty-five ninety-one. three four zero.
		12:15:37.2 **CTR**	Giant thirty-five ninety-one Houston Center roger.
12:15:40.7 **HOT-1**	cool.		
12:15:42.7 **HOT-1**	it's all good like butter on a biscuit.		
12:15:43.6 **HOT-2**	eh yuppp.		
12:16:40.6 **CAM-1**	once they hand us off to approach I'll ask 'em which runway their gunna give us so.		
12:16:47.1 **CAM-1**	they should tell us- sometimes they don't.		
12:16:49.8 **HOT-2**	yeah.		
		12:18:45.4 **CTR**	Giant thirty-five ninety-one descend via LINKK one arrival Beaumont altimeter two niner eight eight.
		12:18:53.0 **RDO-1**	alright two niner eight eight descend via the uh LINKK one arrival Giant uhh- any idea which runway we can expect?

Intra-Aircraft Communication		Over-the-Air Communications	
		12:18:59.2 **CTR**	uhhh there should be a note I don't issue a transition.
		12:19:01.9 **RDO-1**	okie doke.
12:19:02.5 **HOT-2**	(seven) thousand.		
12:19:19.8 **HOT-1**	yeah I don't know if they don't understand or- 'cause it does make a difference on your altitude- which runway you get.		
12:19:26.2 **HOT-2**	really doesn't matter.		
12:19:27.3 **HOT-1**	whatever- we get closer.		
12:19:45.8 **HOT-2**	and it's especially worse if you planned it the other way around like having six in- and then they change it to seven and you don't (know/notice) so then you missed it.		
12:19:56.8 **HOT-1**	yup.		
12:19:56.9 **HOT-2**	so high to low is not so bad- ya know.		
12:19:59.3 **HOT-1**	yeah I'd rather be higher–		
12:20:00.0 **HOT-2**	I'd rather be higher than lower. yea.		

Intra-Aircraft Communication		Over-the-Air Communications
12:20:00.6 **HOT-1**	higher than lower. [In unison with HOT-2.]	
12:20:02.0 **HOT-2**	ya know but- but-	
12:20:19.8 **CAM**	[Sound of clunk similar to an unknown cockpit item being moved.]	
12:20:31.2 **HOT-2**	well I think the difference in altitude is only 'cause- ya gunna be at- the shorter distance-	
12:20:37.6 **HOT-1**	it's shorter distance- yeah.	
12:20:38.5 **HOT-2**	but they wanna get ya down lower that's all.	
12:21:18.9 **CAM**	[Change in CAM signal to noise ratio. The CAM recorded at a lower decibel level for the remainder of the recording.]	
12:23:45.4 **HOT-2**	approaching top of descent.	
12:23:49.9 **HOT-1**	say again?	
12:23:50.9 **HOT-2**	I said ap- I said approaching top of descent.	
12:24:52.7 **HOT-2**	okay (*ing) three four zero.	

Intra-Aircraft Communication		Over-the-Air Communications	
		12:24:54.2 **RDO-1**	and Giant thirty-five ninety-one three four zero's beginning our descent.
		12:24:58.1 **CTR**	Giant thirty-five ninety-one roger.
12:25:06.6 **CAM**	[Sound similar to increase in pack airflow noise.]		
12:25:57.6 **HOT-1**	he didn't give us a speed did he? alright. [This comment came immediately after ATC issued a speed restriction for another aircraft on frequency which is not transcribed.]		
12:26:02.6 **HOT-1**	make sure I didn't miss something.		
12:26:04.1 **HOT-2**	(this)- this- two eighty and (uhh so).		
12:26:07.8 **HOT-1**	yeah but you put that in there.		
12:26:09.1 **HOT-2**	huh?		
12:26:09.7 **HOT-1**	you put that in there right?		
12:26:11.3 **HOT-2**	what?		
12:26:11.7 **HOT-1**	two eighty. he didn't give us two eighty.		

Intra-Aircraft Communication		Over-the-Air Communications
12:26:13.8 **HOT-2**	no two eighty's on the approach I just put the descent so I just put it in as a- it can go ta- you can descend faster and then have it transition to two eighty when it's time but-	
12:26:22.0 **HOT-1**	so what you wanna go three ten?	
12:26:23.4 **HOT-2**	uhyeah.	
12:26:24.7 **HOT-1**	ummm.	
12:26:26.9 **HOT-2**	when we were doin' the first of the descent it was like–	
12:26:29.3 **HOT-1**	right.	
12:26:29.4 **HOT-2**	– overspeeding- so-	
12:26:31.4 **HOT-1**	good.	
12:26:33.2 **HOT-1**	three ten?	
12:26:34.0 **HOT-2**	execute.	
12:28:03.7 **HOT-2**	BBQUE at two eighty (so).	
12:28:06.0 **HOT-1**	what's that?	

Intra-Aircraft Communication		Over-the-Air Communications
12:28:06.5 **HOT-2**	BBQUE at two eighty so we gotta- *.	
12:28:07.8 **HOT-1**	yup	
12:28:11.3 **HOT-1**	should be slowin' down.	
12:28:12.7 **HOT-2**	umm I don't know so may- may have to put it in yourself.	
12:28:17.7 **HOT-1**	yeah we're (on/armed)- yeah it should.	
12:28:18.9 **HOT-2**	okay.	
12:28:19.4 **HOT-1**	should be alright.	
12:28:21.5 **HOT-2**	I think it should.	
12:28:59.2 **HOT-2**	* (*/eighty).	
12:29:01.2 **HOT-2**	put (it/the) (three/two) eighty in for the des–	
12:29:03.7 **HOT-2**	confirm.	
12:29:04.7 **HOT-1**	execute.	

Intra-Aircraft Communication		Over-the-Air Communications	
12:29:13.4 **CAM**	[Sound similar to soft clack.]		
12:29:30.6 **CAM**	[Sound similar to soft clack.]		
12:29:47.0 **HOT-1**	it should slow down.		
12:29:48.5 **HOT-2**	yeahh.		
12:29:49.9 **HOT-2**	I think the thermal is causing these uplift(in/and)–		
12:29:52.5 **HOT-1**	yeah we're way below our path anyway so-		
12:29:54.1 **HOT-2**	yeahh.		
12:29:57.9 **CAM**	[Sound similar to soft clack.]		
12:30:07.7 **CAM-2**	(transition altitude.)		
12:30:09.4 **CAM-1**	two eight niner eight eight		
		12:30:13.1 **CTR**	Giant thirty-five ninety-one contact Houston Approach one one niner point six two.
		12:30:17.9 **RDO-1**	nineteen sixty-two good weekend.

Intra-Aircraft Communication		Over-the-Air Communications	
12:30:23.6 **CAM**	[Sound similar to soft clack.]		
		12:30:31.3 **RDO-1**	Houston good afternoon Giant ah thirty-five ninety-one seventeen eight descending via the LINKK and we have sierra.
		12:30:37.7 **APP**	Giant thirty-five ninety-one- heavy- Houston- good afternoon- it looks like tango is current. altimeter is two niner niner one and they might be updating that as well. you can fly the runway two six left transition.
		12:30:49.9 **RDO-1**	two six left transition thank you much and ninety-one on the meter.
12:30:52.9 **CAM**	[Sound similar to two mic clicks.]		
12:30:53.5 **HOT-1**	ninety-one.		
12:30:54.5 **HOT-2**	set.		
12:30:55.5 **HOT-1**	ninety-one.		
12:30:56.4 **HOT-2**	okay.		
12:30:58.4 **HOT-1**	two six left and do do do do the departure.		
12:31:04.7 **HOT-1**	LINKK two six left.		

Intra-Aircraft Communication		Over-the-Air Communications
12:31:10.2 **HOT-1**	ahhh...	
12:31:15.8 **HOT-1**	GARRR?	
12:31:16.9 **HOT-2**	yeah.	
12:31:18.3 **HOT-2**	two six left.	
12:31:20.8 **HOT-2**	so then the-	
12:31:23.3 **HOT-2**	GARRR.	
12:31:24.6 **HOT-2**	GARRR at seven thousand.	
12:31:27.7 **HOT-1**	I mean you should still be GARRR- right?	
12:31:28.9 **HOT-2**	yeah. still GARRR.	
12:31:29.7 **HOT-1**	yeah.	
12:31:30.5 **HOT-2**	yeah,	
12:31:34.7 **HOT-1**	VANNN- LINKK GILLL GARRR VANNN MKAYE- that's good- okay.	

Intra-Aircraft Communication		Over-the-Air Communications
12:31:37.9 **HOT-2**	I agree- same.	
12:31:39.0 **HOT-1**	alright now- uhhh approach.	
12:31:50.0 **HOT-1**	(chillin')	
12:31:58.0 **HOT-1**	alright- altimeter's two nine nine one.	
12:32:02.6 **HOT-1**	set- um- approach check's complete.	
12:32:02.7 **HOT-2**	two nine–	
12:32:05.0 **HOT-2**	checklist complete.	
12:32:12.5 **HOT-1**	alright one oh nine seven.	
12:32:15.1 **HOT-1**	two sixty-seven.	
12:32:19.1 **HOT-1**	aaand...	
12:32:30.9 **HOT-1**	evaluation looks fine- everything looks good so-	
12:32:37.8 **HOT-2**	LINKK between fifteen and twelve.	
12:32:42.6 **HOT-2**	I think it's doin' a bad job today (but)-	

Intra-Aircraft Communication		Over-the-Air Communications
12:32:44.0 **HOT-1**	what's that I can't hear ya.	
12:32:44.9 **HOT-2**	I sayyy LLL-LINKK between fifteen and twelve I think is doin' a bad job.	
12:32:49.5 **HOT-2**	[sound of stutter.]	
12:32:53.2 **HOT-2**	on this *–	
12:32:53.6 **HOT-1**	that looks to me like it's on glide.	
12:32:55.6 **HOT-2**	yeahhh it's on glide buttt- I I think it-	
12:32:59.0 **HOT-1**	it got confused back there cause we passed- two thousand feet above what it was planning on doing.	
12:33:04.8 **HOT-2**	yeah.	
12:33:05.5 **HOT-1**	I mean two- two thousand feet below.	
12:33:06.2 **HOT-2**	oh okay- it's coming in now. it's dropping the speed- should have dropped the speed a little sooner than that I think.	
12:33:14.3 **HOT-2**	it's within ten knots so it's good.	

Intra-Aircraft Communication		Over-the-Air Communications
12:33:19.5 **HOT-2**	should be two fifth- two fifty.	
12:33:25.9 **HOT-1**	yeah it's it's doin' it.	
12:33:27.2 **HOT-2**	yeah.	
12:33:27.6 **HOT-1**	we're just now LINKKs two fifty two so-	
12:33:29.4 **HOT-2**	yeah.	
12:33:32.8 **HOT-2**	eh the next one–	
12:33:34.4 **HOT-1**	I'm like you though I don't trust this thing.	
12:33:36.3 **HOT-2**	ohhh I (know)	
12:33:37.3 **HOT-1**	too- too many years in the Embraer I don't trust all this automatic flight-	
12:33:39.7 **HOT-2**	ah yeah.	
12:33:41.9 **HOT-1**	we're in a tuna can [Tuna Can - company terminology for a 767-200.] the other day- it started pickin' up the glideslope- it started doin' thisss-	
12:33:45.6 **HOT-2**	ohh yeah yeah.	

Intra-Aircraft Communication		Over-the-Air Communications	
12:33:46.1 **HOT-1**	and then- this thing was doin' way worse.		
12:33:48.1 **HOT-2**	where- where were you goin'?		
12:33:50.9 **HOT-1**	either into Cincinnati or Atlanta- I can't- I think we're goin' into Atlanta- at night.		
12:33:53.8 **HOT-2**	Atlanta.		
12:33:56.2 **HOT-1**	so finally at about four thousand feet I just cut- clicked it off and flew it.		
12:34:01.6 **HOT-2**	GILLL at two forty.		
12:34:02.9 **HOT-1**	but it was very confused.		
12:34:04.6 **HOT-2**	yeah.		
		12:34:08.8 **APP**	Giant thirty-five ninety-one heavy there is a little bit of light- well now it's showin' a little bit of heavy- light to heavy precipitation just west off it looks like VANNN and it is moving eastbound so once you get in closer if we need to go vectors around it and we'll we'll be able to accommodate that.
		12:34:25.2 **RDO-1**	alright thanks for the heads up uh Giant thirty-five ninety-one.
		12:34:29.6 **RDO-?**	[Sounds similar to two mic clicks.]

Intra-Aircraft Communication		Over-the-Air Communications	
		12:35:16.7 **APP**	Giant thirty-five ninety-one heavy contact approach on one two zero point six five.
		12:35:21.3 **RDO-1**	twenty sixty-five have a good afternoon.
		12:35:23.7 **APP**	you too.
12:35:25.5 **HOT-1**	love you.		
		12:35:39.6 **RDO-1**	hello approach Giant umm thirty-five ninety-one eleven four descending via the LINKK and we have uh tango.
		12:35:47.4 **APP**	'kay Giant thirty-five ninety-one Houston Approach it will be vectors runway two six left. how (do) you wanna get around this stuff? you wanna go- uh- to the east of it and go- join up on the north side or what do you wantin' to do?
		12:35:59.3 **RDO-1**	one second I'll get right back with you.
12:36:03.7 **HOT-2**	okay.		
12:36:07.1 **HOT-2**	okay – I just had a (* / fff) [End of statement cut off by a quick exhale, or the sound of possible phonetic “F”.]		
12:36:09.4 **HOT-1**	[Sound of quick laugh.]		

Intra-Aircraft Communication		Over-the-Air Communications	
12:36:09.9 **HOT-2**	your controls.		
12:36:10.8 **HOT-1**	great. my controls.		
12:36:11.8 **HOT-2**	ahh *.		
12:36:12.5 **HOT-1**	ahhh-		
12:36:13.4 **HOT-2**	LNAV VNAV center autopilot.		
12:36:14.2 **HOT-1**	want to go to- east side?		
12:36:17.2 **HOT-2**	ehuh?		
12:36:19.2 **HOT-2**	LNAV VNAV center autopilot.		
12:36:19.3 **HOT-1**	alright we can go around it- alright my controls.		
12:36:20.6 **HOT-2**	so- okay-		
		12:36:21.4 **RDO-2**	Giant uh thirty-five uh six- sorry thirty-five and ninety-one we will go on the west side.

Intra-Aircraft Communication | **Over-the-Air Communications**

12:36:28.9
APP alright the only problem we have with that right now there's a bunch of departures departin' out right at ya so we're gunna do–

12:36:33.4
RDO-2 okay- depart- okay–

12:36:34.0
APP all the way down.

12:36:34.9
RDO-2 okay then we'll go on the east side then that's fine just go ahead and direct us.

12:36:40.4
HOT-1 we got lots of fuel so-

12:36:41.7
HOT-2 yeah.

12:36:45.4
APP Giant thirty-five ninety-one descend and maintain three thousand- hustle all the way down I'm gunna get ya west of this weather and northbound for a baseleg.

12:36:51.6
RDO-2 down to three thousand and all the way down Giant thirty-five uh ninety-one so we gunna delete the arrival just gunna go straight down.

12:36:55.2
CAM-1 three thousand set.

12:37:00.4
HOT-2 okay so one second. okay so we gunna hold off on that checklist. right?

Intra-Aircraft Communication		Over-the-Air Communications	
12:37:07.2 **HOT-2**	E-fy. [EFI button.]		
12:37:08.5 **HOT-?**	E-fy.		
12:37:08.9 **HOT-2**	okay I got it back.		
12:37:09.5 **HOT-1**	now it's back. [Sound of quick laugh.]		
12:37:10.1 **CAM**	[Sound of quick two beeps. Frequency not discernible.]		
12:37:11.5 **HOT-2**	I press the E-fy button- it fixes everything.		
12:37:13.7 **HOT-1**	oh ya ya.		
		12:37:16.2 **APP**	and Giant thirty-five ninety-one turn left heading two seven zero.
		12:37:19.5 **RDO-1**	left turn two seven zero Giant ninety-five er um thirty five ninety-one.
12:37:22.6 **HOT-2**	okay.		
12:37:23.5 **HOT-2**	two seven zero.		
12:37:23.9 **HOT-1**	alright your controls.		

Intra-Aircraft Communication		Over-the-Air Communications
12:37:24.8 **HOT-2**	my controls.	
12:37:27.4 **HOT-1**	alright so I will pull it out from- umm where see where they pull us in.	
12:37:30.4 **HOT-2**	okay.	
12:37:31.0 **HOT-1**	probably from JEPNI.	
12:37:32.3 **HOT-2**	okay.	
12:37:46.3 **HOT-1**	you want it out from JEPNI or GRIEG?	
12:37:48.0 **HOT-2**	* *.	
12:37:51.9 **CAM-2**	umm let's make it GRIEG.	
12:37:54.7 **HOT-1**	GRIEG	
12:37:58.2 **HOT-1**	GRIEG and two sixty-seven.	
12:38:00.6 **HOT-2**	okay.	
12:38:00.9 **HOT-1**	GRIEG two sixty-seven.	
12:38:02.2 **HOT-2**	'kay flaps one.	

Intra-Aircraft Communication		Over-the-Air Communications	
12:38:04.8 **CAM**	[Sound of mechanical click.]		
12:38:05.1 **HOT-2**	thank you.		
12:38:06.1 **HOT-1**	confirm. confirm.		
12:38:07.3 **HOT-2**	execute.		
12:38:08.7 **HOT-1**	LNAVs available.		
12:38:09.9 **HOT-2**	LNAV is...		
12:38:14.3 **HOT-1**	not on intercept heading.		
12:38:15.0 **HOT-2**	no (your on/it's on) a heading right?		
12:38:16.7 **HOT-1**	oh we're supposed to be on heading- yeah.		
12:38:17.9 **HOT-2**	yeah.		
12:38:31.1 **CAM**	[Sound of click.][2]		
		12:38:35.1 **APP**	Giant thirty-five ninety-one in about another eighteen miles or so we'll cut you due north(bound) for a base leg.

[2] The group was reconvened on November 14, 2019. This sound was not initially heard during the first transcription sitting of the group on March 5, 2019. After the generation of the Sound Spectrum Study, which can be found in the public docket for this accident, all members of the group were able to detect this sound when directed to the area of interest on the recording.

Intra-Aircraft Communication		Over-the-Air Communications	
12:38:40.3 **CAM**	[Sound of four beeps within a duration of .75 seconds at a frequency of 1200 Hz.][3]		
		12:38:41.4 **RDO-1**	sounds good uh Giant thirty-five ninety-one.
		12:38:43.6 **APP**	it is severe clear on the other side of this stuff so you'll have no problem gettin' the airport *(either).
12:38:43.6 **CAM-2**	(oh)		
12:38:44.0 **CAM**	[Sound similar to a mechanical click.]		
12:38:45.0 **CAM-2**	woah. [Spoken in elevated voice.]		
12:38:45.9 **CAM-2**	(where's) my speed my speed [Spoken in elevated voice.]		
12:38:46.9 **CAM**	[Sound similar to louder mechanical click.]		
		12:38:47.3 **RDO-1**	okay.
12:38:47.9 **CAM**	[Sound similar to multiple random thumping noises.]		

[3] Refer to Sound Spectrum Study for a detailed examination of tones detected on the recording.

Intra-Aircraft Communication		Over-the-Air Communications
12:38:48.0 **HOT-2**	we're stalling. [Spoken in elevated voice.]	
12:38:50.5 **HOT-2**	stall. [Exclaimed.]	
12:38:51.9 **HOT-?**	#.	
12:38:52.3 **HOT-2**	oh Lord have mercy myself. [Spoken in elevated voice.]	
12:38:53.3 **CAM**	[Sound similar to multiple random thumping noises.]	
12:38:53.9 **HOT-2**	Lord have mercy. [Exclaimed.]	
12:38:55.1 **HOT-2**	@Capt. [Spoken in elevated voice.]	
12:38:55.7 **HOT-1**	what's goin' on?	
12:38:56.0 **HOT-2**	(Lord)– [Spoken in elevated voice.]	
12:38:56.3 **CAM**	[Sound of 1000 Hz series of beeps with approximately .25 second spacing begin. Group could not determine if audible sound lasted until end of recording.] [4]	
12:38:56.4 **HOT-2**	@Capt. [Spoken in elevated voice.]	

[4] Refer to Sound Spectrum Study for a detailed examination of tones detected on the recording.

Intra-Aircraft Communication		Over-the-Air Communications
12:38:56.6 **CAM-3**	what's goin' on? [Spoken in an elevated voice.]	
12:38:56.8 **HOT-?**	[Sound of rapid breathing.]	
12:38:57.4 **HOT-2**	@Capt-	
12:38:58.1 **CAM**	[Sound of quick series of four beeps at 1200 Hz.] [5]	
12:38:58.9 **CAM**	[Sound of longer duration pulse tone about 1000 Hz, similar to Siren. Group could not determine if audible sounds lasted until end of recording.] [6]	
12:38:59.4 **CAM-3**	* pull up. [Shouted.]	
12:39:00.9 **HOT-2**	[Unintelligible shout.]	
12:39:02.0 **HOT-?**	(oh God). [Shouted.]	
12:39:02.0 **HOT-2**	Lord * * you have my soul. [Shouted.]	
1239:03.9	**END OF TRANSCRIPT** **END OF RECORDING**	

[5] Refer to Sound Spectrum Study for a detailed examination of tones detected on the recording.
[6] Refer to Sound Spectrum Study for a detailed examination of tones detected on the recording.

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