NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

February 26, 2015

Group Chairman's Factual Report

OPERATIONAL FACTORS

DCA14MA081

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A. ACCIDENT

Location: Philadelphia International Airport, PA (PHL)
Date: March 13, 2014
Flight: AWE1702
Time: 1824 EDT[1] (2224Z)
Airplane: A320-214, Registration N113UW (Serial #1141)

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C. SUMMARY

On March 13, 2014, at about 1830, US Airways flight 1702, an Airbus A320, N113UW, experienced a nose gear collapse and other damage after rejecting the takeoff on runway 27L at Philadelphia International Airport (PHL), Philadelphia, Pennsylvania. The airplane came to rest on the edge of the runway, and the passengers exited the aircraft via the emergency slides. There were no injuries to the passengers and crew members and the airplane was substantially damaged. The flight was operating under 14 Code of Federal Regulations Part 121 as a regularly scheduled passenger flight between PHL and Fort Lauderdale/Hollywood International Airport (FLL), Fort Lauderdale, Florida. Day visual meteorological conditions prevailed at the time.

[1] All times are eastern daylight time (EDT) based on a 24-hour clock, unless otherwise noted.
[2] On December 9, 2013, American Airlines and USAirways merged airlines. At the time of the accident, the US Airline Pilots Association (USAPA) represented the pilots of USAirways and was given Party Status to the AWE1702 investigation. On September 16, 2014, the National Mediation Board ruled that the APA was the legal bargaining agent for the two carriers' pilots (American and USAirways). The AWE1702 NTSB Investigator in Charge (IIC) gave APA Party Status to the investigation on October 2, 2014.

D. DETAILS OF THE INVESTIGATION

The Operations Group (the "Group") and Human Performance Group Chairmen did not launch to the accident site in Philadelphia, Pa.

From March 13, 2014 to March 24, 2014 the Group collected crew statements, flight documents, training records and company manuals for review.

From March 25-26, 2014, the Group conducted accident flight crew interviews and simulator work in a USAirways A320 full flight simulator (FFS) at the USAirways training facility in Charlotte, NC.

On April 18, 2014, the Operations and Human Performance Group Chairmen traveled to Toulouse, France for an Airbus presentation on flight phase alerts during takeoff, and simulator work in an Airbus 320 engineering simulator.

From April 28, 2014 to June 25, 2014, the Group conducted additional interviews and reviewed USAirways and Airbus manuals and training material. FAA certification and medical information for the accident crew were requested and reviewed.

From June 2-4, 2014, the Group conducted interviews of USAirways A320 training and Flight Safety personnel at the USAirways training facility in Charlotte, NC.

On August 4, 2014 the Group conducted FAA interviews with the USAirways Principal Operations Inspector (POI) and A320 Aircrew Program Manager (APM).

E. FACTUAL INFORMATION

1.0 History of Flight

The accident occurred on the first day of a four-day Charlotte A320 pairing (94391), and the third leg of the day. The captain began his day with a commute on a 0630 flight from FLL to Charlotte/Douglas International Airport, North Carolina (CLT), arriving into CLT around 0830. The captain had a conversation with the CLT Chief Pilot while in Charlotte, and checked in for his 1035 trip at about 0930. The FO began her day by driving to the airport from her Charlotte, North Carolina home.

The first two flights from CLT to Tampa International Airport (TPA), then to PHL, were uneventful. The inbound flight to PHL arrived on schedule at 1649 at gate C21, and the accident crew changed gates and airplanes for the scheduled 1750 departure to FLL from gate B8.

According to crew interviews, upon arrival at the accident airplane (N113UW), the FO did the cockpit preparation while the captain spoke with the dispatcher.[3] The FO initialized the Flight Management Computer (FMC) with the Air Traffic Control-provided flight plan, and manually

[3] According to the USAirways Flight Operations Manual (FOM) 12-3 Flight Release, the station agent will print the flight paperwork (Release, weather package and TPS departure plan) approximately 60 minutes prior to departure.

entered the departure runway into the FMC. According to crew interviews, both pilots verified the Air Traffic Control (ATC) routing loaded into the FMC while still at the gate prior to pushback,[4] however neither pilot realized that the departure runway loaded into the FMC was runway 27R instead of the anticipated runway 27L.[5]

AWE1702 pushed back from gate B8 at about 1752, and the taxi out was normal. There were 149 passengers, 2 pilots and 3 flight attendants onboard, and the airplane had been fueled to 24,720 pounds. The captain was the pilot flying (PF) and the FO was the pilot monitoring (PM). The weather reported at 1754 was clear skies and 10 statute miles visibility, temperature 0°C (Celsius), dewpoint -21°C, and winds from 290° at 18 knots with gusts 28 knots (peak winds at 1713 were recorded from 300° at 33 knots). ATIS[6] information Yankee called for runway 27L as the departure runway. AWE1702 had been given an Expect Departure Clearance Time (EDCT) of 1829, and the captain elected to conduct a single-engine taxi.

At 1754:33, AWE1702 received the final weight and balance information for the flight via ACARS,[7] and according to the FO interview, she loaded the weight and balance information into the FMC via uplink.[8] She could not remember if she uplinked the takeoff data or manually entered the V-speeds and FLEX[9] temperature information into the Multipurpose Control Display Unit (MCDU).[10]

At 1808:20, AWE1702 contacted PHL Ground Control for taxi instructions from "spot two," and the ATC Ground controller advised them that the departure runway was 27L, and provided them with taxi instructions to runway 27L.[11]

At 1819:30 the PHL Tower Controller advised AWE1702 that they were number six for departure from runway 27L. At 1821:23, the Tower Controller advised AWE1702 they would be next for departure, and AWE1702 acknowledged their sequence 4 seconds later. According to the FO, the crew then started the second engine and conducted a flight control check. The FO started to read the taxi checklist when she got a call from a flight attendant advising that a passenger was in the bathroom. The flight attendant then told her the passenger was returning to their seat, and the FO stated that she continued the checklist as the captain was taxiing toward runway 27L.

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[4] For additional information, see Section 15.2.1 ATC Route Clearance Verification of this Factual Report.
[5] For additional information, see Section 15.10.2 No V-speeds, of this Factual Report.
[6] Automatic Terminal Information Service (ATIS) is the continuous broadcast of recorded noncontrol information in selected high activity terminal areas. Source: Aeronautical Information Manual (AIM), Section 4-1-13.
[7] ARINC Communication Addressing and Reporting System (ACARS) is a digital datalink system for transmission of short, relatively simple messages between aircraft and ground stations via radio or satellite.
[8] Uplink data is sent to the airplane via the ACARS system through the VHF3 radio when set in DATA mode. This allows the pilot to select an "uplink" key in the Multipurpose Control Display Unit (MCDU) that will populate performance data into the FMC.
[9] FLEX is a reduced takeoff thrust setting. For the purposes of this Factual Report, the term "FLEX" will refer to the reduced thrust setting, and the term "FLX" will refer to the physical position of the thrust levers. For additional information on FLEX takeoffs and takeoff data entry, see Section 15.5 Takeoff Data Entry of this Factual Report.
[10] Multipurpose Control Display Unit. Pilots use the MCDU to enter information into the FMC. For additional information, see Section 14.8 Multipurpose Control Display Unit (MCDU) of this Factual Report.
[11] For additional ATC information, see Attachment 5 - Air Traffic Control.

At 1822:35 AWE1702 was cleared to line up and wait on runway 27L. As AWE1702 taxied onto runway 27L, while completing the Taxi Checklist "below the line" items, the captain noticed that runway 27R had been inserted into the FMC instead of runway 27L, and requested the FO to change the runways in the FMC.

At 1823:26 AWE1702 was given a heading of 230 degrees on departure and a clearance for takeoff. According to crew interviews and flight data recorder (FDR) data, the captain set the thrust levers in the FLX detent, and the crew received an Electronic Centralized Aircraft Monitoring (ECAM) message and chime indicating that the thrust was not set.[12] According to the crew interviews, he asked the FO what it was, and she said "thrust not set," and the captain said "the thrust is set." At about 85 knots (71 knots groundspeed), FDR data indicated the thrust levers were momentarily reduced to the CL (climb) detent and then immediately returned to FLX detent.

According to crew interviews, the captain and FO then noticed that there were no V-speeds indicated on their Primary Flight Displays (PFDs),[13] and as the airplane accelerated through 80 knots, an aural "Retard" alert sounded in the cockpit.[14] According to crew interviews, the captain told the FO "we'll continue and take care of it in the air."[15]

According to the crew interviews, during the takeoff the captain stated that he "felt like the airplane was totally unsafe to fly" and, the captain elected to reject the takeoff.[16] According to crew interviews, physical evidence, FDR data and security camera footage, the airplane bounced during the rejected takeoff and incurred a tailstrike, and the nose gear collapsed. At 1824:48, AWE1702 advised that they were aborting the takeoff on runway 27L as the airplane came to rest on the left side of runway 27L. At 1829:14, AWE1702 advised the PHL tower that they were evacuating the airplane.

2.0 Flight Crew Information

The accident crew consisted of a captain, a first officer (FO) and 3 flight attendants. The captain and FO told NTSB investigators that they had flown together previously, but could not recall specific dates. The accident occurred on the third leg of the first day of a 4 day Charlotte-based A320 pairing (pairing number 94391). The trip started in CLT with a scheduled report time of 1035. The crew flew from CLT to Tampa International Airport (TPA) for the first leg, and TPA to PHL on the second leg, arriving into PHL at 1649. The scheduled departure time for AWE1702 was 1750.

[12] For more information on the ECAM, see Section 14.6 Electronic Centralized Aircraft Monitoring (ECAM) of this Factual Report.

[13] See Attachment 1 – Interview Summaries. For more information on the PFD, see Section 14.4.1 Primary Flight Displays (PFD) of this Factual Report.

[14] For more information on the "Retard" aural alert, see Section 15.9.3 "Retard" Aural Alert on Takeoff of this Factual Report.

[15] See Attachment 1 – Interview Summaries.

[16] According to his interview, the captain stated that the airplane became airborne prior to his decision to reject the takeoff. See Attachment 1 – Interview Summaries.

2.1 The Captain

The captain was 61 years old and resided in Pompano Beach, Florida. His date of hire with USAirways was March 3, 1986.[17] His background was all civilian flying, including flight instruction and flying for a commuter airline for about 5 and a half years before being employed as a pilot with Piedmont Airlines.[18]

The captain estimated his total flying time at about 23,800 hours, including about 7,500 hours as pilot in command and about 4,500 hours on the A320.

He held an Airline Transport Pilot certificate which included a type rating on the A320 and a first class medical certificate with a limitation that stated "Not valid for any class after May 31, 2014." According to the captain, his medical certificate included a special issuance related to a previous bypass surgery in February 2011.[19]

A review of the FAA PTRS[20] database showed no records or reports of any previous aviation incidents or accidents involving the captain. A search of the National Driver Register found no record of driver's license suspension or revocation.

2.1.1 The Captain's Pilot Certification Record[21]

Private Pilot – Airplane Single Engine Land certificate issued February 5, 1979.

Private Pilot – Airplane Single Engine Land, Instrument Airplane certificate issued August 29, 1979.

Commercial Pilot – Airplane Single Engine Land, Instrument Airplane certificate issued September 18, 1979.

Commercial Pilot – Airplane Single and Multi-Engine Land, Instrument Airplane certificate issued October 3, 1979.

Flight Instructor – Airplane Single Engine certificate issued November 23, 1979.

Flight Instructor – Airplane Single Engine Instrument Airplane certificate issued December 12, 1979.

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[17] The captain was originally hired by Piedmont Airlines. USAir purchased Piedmont Airlines in 1987, and merged operations in 1989. USAir changed its name to USAirways on November 12, 1996.
[18] USAirways (then called USAir) acquired Piedmont Airlines in 1989.
[19] For additional information on the captain's medical condition, see the Human Performance Group Chairman's Factual Report.
[20] The Program Tracking and Reporting Subsystem (PTRS) is a comprehensive information management and analysis system used in many Flight Standards Service (AFS) job functions. It provides the means for the collection, storage, retrieval, and analysis of data resulting from the many different job functions performed by Aviation Safety Inspectors (ASIs) in the field, the regions, and headquarters. This system provides managers and inspectors with current data on airmen, air agencies, air operators, and many other facets of the air transportation system. Source: FAA.
[21] Source: FAA.

Flight Instructor – Airplane Single and Multi-Engine Instrument Airplane certificate issued October 30, 1980.

Renewed October 14, 1982; July 27, 1984; November 12, 1985; November 5, 1987;

Airline Transport Pilot – Airplane Multi-Engine Land, Commercial Privileges Airplane Single Engine Land certificate issued April 30, 1982.

Airline Transport Pilot – Airplane Multi-Engine Land SD-3, Commercial Privileges Airplane Single Engine Land certificate issued July 27, 1984.

Airline Transport Pilot – Airplane Multi-Engine Land SD-3 DHC-8, Commercial Privileges Airplane Single Engine Land certificate issued November 9, 1985.

Flight Engineer – Turbojet Powered certificate issued April 25, 1986.

Airline Transport Pilot – Airplane Multi-Engine Land SD-3 DHC-8 B-757 B-767 (B-757 B-767 Circ Apch VMC Only), Commercial Privileges Airplane Single Engine Land certificate issued January 14, 1999.

Airline Transport Pilot – Airplane Multi-Engine Land SD-3 DHC-8 B-757 B-767 A-320 (B-757 B-767 A-320 Circ Apch VMC Only), Commercial Privileges Airplane Single Engine Land certificate issued February 21, 2001.

2.1.2 The Captain's Pilot Certificates and Ratings Held at Time of the Accident[22]

Flight Engineer (issued February 4, 2009)[23]
Turbojet Powered

Airline Transport Pilot (issued February 4, 2009)
Airplane Multi-Engine Land
SD-3 DHC-8 B-757 B-767 A-320 (B-757 B-767 A-320 Circ Apch VMC Only) Type Ratings
Commercial Privileges Airplane Single Engine Land

Medical Certificate First Class (issued November 21, 2013)
Limitations: Not valid for any class after May 31, 2014.[24]

2.1.3 The Captain's Training and Proficiency

USAirways Seniority Date	March 3, 1986
Date Upgraded to Captain on A319/320/321	February 21, 2001
Date of Initial Type Rating on A319/320/321	February 21, 2001

[22] Source: FAA.
[23] Captain's original Flight Engineer and ATP certificates were reissued on February 4, 2009 to remove the pilot's social security number.
[24] For additional information, see Human Performance Group Chairman's Factual Report.

Date of Most Recent Proficiency Training	December 18, 2013
Date of Most Recent Proficiency Check	December 19, 2013
Date of Most Recent PIC Line Check	November 21, 2013

2.1.4 The Captain's Flight Times[25]

The captain's flight times provided to the NTSB:

Total pilot flying time	23,830
Total Pilot-In-Command (PIC) time	7,500
Total A319/320/321 flying time	4,457
Total A319/320/321 PIC time	4,457
Total flying time last 24 hours	6
Total flying time last 7 days	6
Total flying time last 30 days	38
Total flying time last 90 days	159

2.1.5 The Captain's Personal Background

See Human Performance Group Chairman's Factual Report.

2.1.6 Captain's Authority

14 CFR 91.3 "Responsibility and authority of the pilot in command" stated:

> *(a) The pilot in command of an aircraft is directly responsible for, and is the final authority as to, the operation of that aircraft.*
>
> *(b) In an in-flight emergency requiring immediate action, the pilot in command may deviate from any rule of this part to the extent required to meet that emergency.*
>
> *(c) Each pilot in command who deviates from a rule under paragraph (b) of this section shall, upon the request of the Administrator, send a written report of that deviation to the Administrator.*

Further, 14 CFR 121.533 "Responsibility for operational control: Domestic operations" (d) and (e) stated:

> *(d) Each pilot in command of an aircraft is, during flight time, in command of the aircraft and crew and is responsible for the safety of the passengers, crewmembers, cargo, and airplane.*

[25] Flight times were provided to the NTSB by the captain during the interview and by USAirways on NTSB form 6120.

(e) Each pilot in command has full control and authority in the operation of the aircraft, without limitation, over other crewmembers and their duties during flight time, whether or not he holds valid certificates authorizing him to perform the duties of those crewmembers.

According to the USAirways Flight Operations Manual (FOM), Section 1.3.4, USAirways expected its captains to use common sense and good judgment, especially in those situations not specifically covered by the FOM. The captain was the pilot in command (PIC) of the aircraft and had authority over all assigned crewmembers from the time they report for duty until termination of the flight. The USAirways FOM, Section 1.3.4, further stated the following:

Crewmembers will promptly comply with a captain's order. Conflicting procedures and instructions should be brought to the captain's attention; however, if the order stands, it is to be obeyed.

The captain is solely responsible for his aircraft, crew and passengers. He is the final authority in Flight Operations matters ensuring all flight operation activities for his flight are completed in accordance with Company policy and procedures. If the captain is dissatisfied with any aspect of the aircraft's airworthiness and/or maintenance status, or if he is not sure the operation can be safely executed, then the operation will stop until he is completely satisfied. This includes, but is not limited to, matters associated with checklists, weight and balance, de/anti-icing, fueling, etc.

2.2 The First Officer

The first officer was 62 years old and resided in Charlotte, North Carolina. She started flying in 1986 and became a certified flight instructor (CFI) flying for Piedmont Aviation for several years before getting hired by CCAir (USAirways commuter) in 1990. She was furloughed for a short time from CCAir before being recalled in 1991 flying the Jetstream. Her date of hire as a pilot for USAirways was March 25, 1999.[26]

She was furloughed from USAirways from March 2, 2002 to April 15, 2007 and according to USAirways' records, was trained on the A320 upon her return to USAirways. On May 18, 2007, the FO failed a Systems and Procedure Validation (SPV). On June 3, 2007, the FO failed to obtain a recommendation for LOE (line oriented evaluation) and received 2 days of additional training. On June 23, 2007, she failed to qualify due to an incomplete OE (operating experience) on the A320.

The FO estimated her total flying time at about 13,000 hours, including about 4,700 hours on the A320.

She held an Airline Transport Pilot certificate which included a type rating on the A320 and a first class medical certificate with a limitation that stated that she must wear corrective lenses and possess glasses for near and interim vision. According to the FO, she had been wearing her glasses on the accident flight, and they came off during the accident sequence. She retrieved a

[26] The FO was originally hired July 2, 1973 as a flight attendant.

spare pair of glasses from her suitcase to read the Quick Reference Handbook (QRH) during the evacuation.[27]

A review of the FAA PTRS database showed no records or reports of any previous aviation incidents or accidents involving the FO. A search of the National Driver Register found no record of driver's license suspension or revocation.

2.2.1 The FO's Pilot Certification Record[28]

Private Pilot – Airplane Single Engine Land certificate issued November 25, 1986.

Private Pilot – Airplane Single Engine Land Instrument Airplane certificate issued October 7, 1987.

Commercial Pilot – Airplane Single Land Instrument Airplane certificate issued February 26, 1988.

Commercial Pilot – Airplane Single and Multiengine Land Instrument Airplane certificate issued April 28, 1988.

Ground Instructor – Basic Ground Instructor certificate issued September 27, 1988.

Flight Instructor – Airplane Single Engine certificate issued September 27, 1988.
Renewed: March 14, 1990.

Flight Instructor – Airplane Single Engine Instrument Airplane certificate issued May 17, 1991.

Airline Transport Pilot – Airplane Multi-Engine Land, Commercial Privileges; Airplane Single Engine Land certificate issued December 13, 1994.

Airline Transport Pilot – Airplane Multi-Engine Land BA-3100, Commercial Privileges Airplane Single Engine Land certificate issued April 30, 1998.

Airline Transport Pilot – Airplane Multi-Engine Land BA-3100, A320 Circ Apch VMC Only, Commercial Privileges Airplane Single Engine Land certificate issued June 10, 2007.

Airline Transport Pilot – Airplane Multi-Engine Land BA-3100, A320 Commercial Privileges Airplane Single Engine Land certificate issued March 18, 2008.

2.2.2 The FO's Pilot Certificates and Ratings Held at Time of the Accident[29]

Flight Instructor (certificate issued May 17, 1991)

[27] See Attachment 1 – Interview Summaries.
[28] Source: FAA.
[29] Source: FAA.

Airplane Single Engine
Instrument Airplane

Airline Transport Pilot (certificate issued March 18, 2008)
Airplane Multi-Engine Land
BA-3100, A320 Type Ratings
Commercial Privileges Airplane Single Engine Land

Medical Certificate First Class (issued December 5, 2013)
Limitations: Must wear corrective lenses and possess glasses for near and interim vision.

2.2.3 The FO's Training and Proficiency

USAirways Pilot Seniority Date	May 25, 1999
Date of Initial Type Rating on A320	June 10, 2007
Date of Most Recent Proficiency Training	May 14, 2013
Date of Most Recent Proficiency Check	May 15, 2013
Date of Most Recent Line Check	October 5, 2013

2.2.4 The FO's Flight Times[30]

The accident F/O's flight times:

Total pilot flying time	13,000
Total flying time in A319/320/321 (SIC)	4,784
Total flying time last 24 hours	6
Total flying time last 7 days	20
Total flying time last 30 days	47
Total flying time last 90 days	163

2.2.5 The FO's Personal Background

See Human Performance Group Chairman's Factual Report.

3.0 Medical and Pathological Information

Both pilots were alcohol and drug tested in PHL following the accident, and test results for both pilots were negative.[31] For additional medical information, see Human Performance Group Chairman's Factual Report.

[30] Flight times were provided to the NTSB by the FO during an NTSB interview and by USAirways on NTSB form 6120.
[31] The drugs tested included Amphetamines (amphetamine, methamphetamine, Ecstasy), Cocaine, Marijuana, Phencyclidine, and Opiates (Codeine, Morphine, 6-MAM). For additional information, see Human Performance Group Chairman's Factual Report.

4.0 Aircraft Information[32]

Photo 1: Accident Aircraft N113UW.

The accident airplane was an Airbus A320-214 (Registration N113UW), Serial number 1141, and was manufactured in 1999. The registered owner was USAirways, Inc., and it held a transport category airworthiness certificate dated February 4, 2000. The airplane had a maximum ramp weight of 170,635 pounds, and had a total passenger seating capacity of 150, plus 4 flight crew seats, 5 cabin crew seats, and 150 passenger seats. At the time of the accident, it had a total of 44,230 airframe hours, and the last recorded inspection occurred on March 3, 2014. A review of NTSB and FAA records found that the accident airplane had not been involved in any previous serious incidents that merited a formal investigation or accidents.[33]

An NTSB review of the accident airplane's maintenance records indicated that on arrival to PHL, the aft lavatory (aircraft left) toilet seat was found defective (log page 8491846), and maintenance corrected the item and closed the discrepancy.[34]

The airplane was powered by two CFM56 Series engines. Each engine was managed by a Full Authority Digital Engine Control (FADEC) system which provides engine indications and thrust limit displays on the upper Electronic Centralized Aircraft Monitoring (ECAM) Engine Warning Display (E/WD).[35] Power settings for the CFM56 were based on a percentage (%) of N1.[36]

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[32] Aircraft information provided by the FAA and USAirways (via NTSB Form 6120).
[33] NTSB source: http://www.ntsb.gov/safetyrecs/private/QueryPage.aspx. FAA source: PTRS.
[34] The NTSB received statements from the flight crew who previously flew the accident airplane, and both pilots indicated there were no flight controls anomalies with the airplane during their flight from FLL to PHL. See Attachment 3 – Crew Statements.
[35] Source: USAirways A319/320/321 TM, Section 17.1.1 General, page 17-1.
[36] N1 refers to rotational speed of the low pressure turbine as a percentage of a nominal "full thrust" value.

5.0 Weight and Balance

USAirways used the SABRE Flight Planning System and the Automated Takeoff Weight and Weight & Balance System. According to the USAirways FOM, Section 6.1.1 Weight and Balance System, US Airways' FAA-approved Weight and Balance (W&B) system provided W&B and Takeoff Weight (TOW) calculations for all flights. Operations Engineering updated TOW and W&B information to comply with manufacturer and FAA operational performance requirements. Central Load Planning (CLP) calculated the final weight and balance data using the automated/manual system and applicable station information. The SABRE Flight Planning System was used for the accident flight.

The automated system incorporated programmed MEL/CDL[37] items, runway closures/restrictions/NOTAMS, and runway conditions. There were no performance related MELs or CDLs on the accident airplane.

The final weight and balance was transmitted to the accident airplane by CLP via ACARS at 1754:33, and per the USAirways Flight Operations Manual (FOM), the captain was required to ensure the final W&B was reviewed, within normal operating limits, and was updated with any changes to fuel, passenger, or cargo load.[38]

WEIGHT & BALANCE / PERFORMANCE (maximum certificated weights in **bold)**		
	Empty Operating Weight	96,800
	Crew Weight	Included above
	Baggage/Cargo Weight (30 lbs forward/2,550 lbs aft)	2,580
	Passenger Weight (149 passengers x 195#/passenger)	29,055
	Zero Fuel Weight (from TPS)	128,435
	Maximum Zero Fuel Weight	**134,480**
	Fuel Weight[39]	24,720
	Ramp Weight	153,155
	Maximum Taxi Weight	**170,635**
	Taxi Fuel Burn	630
	Actual Takeoff Weight	152,525
	Maximum Takeoff Weight (Structural)	**169,754**
	Maximum Takeoff Weight (27R PHL; Landing limited)	156,700
	Estimated Fuel Burn to FLL	14,474
	Estimated Weight on Landing	138,051
	Maximum Landing Weight	**142,198**
	CG (TO)	32.9
	CG Limits (MAC)	32.9
	Nose trim	0.9DN
	Takeoff Flaps (CONF)	CONF 01
	$V_1/V_R/V_2$[40]	157/159/159

[37] Minimum Equipment List/Configuration Deviation List.
[38] Source: USAirways Flight Operations Manual (FOM), Section 6.1.1 Weight and Balance System.
[39] The Final Weight and Balance sent to the accident airplane showed the fuel on board (FOB) as 24,600 pounds. However, the actual fuel load per the fuel slip indicated 24,720 pounds FOB.
[40] According to the TPS and Final Weight and Balance sent to the airplane, the V1/VR/V2 takeoff speeds were identical for runways 27L and 27R (157/159/159). See Attachment 4 – AWE1702 Paperwork.

6.0 Takeoff Performance System (TPS)

According to interviews with the accident crew, the captain arrived at the departure gate of B8 at PHL and received a copy of the flight's departure paperwork, which included the flight release, weather information, and Takeoff Performance System (TPS) Departure Plan. The TPS information contained the following sections:[41]

—Weight Restricted or Capped Flight Warning
—Header
—TPS Performance Adjustments
—Thrust/V-Speed
—Airport Notes
—Airport Analysis Data
—Weight and Balance Data
—Agent Data

The TPS information provided to AWE1702 included takeoff performance information for runways 27L and 27R, and included the following: [42]

RWY	CONF	APU	N1	V1	VR	V2	AT	MTOW
27L	01	OFF	84.3	157	159	159	127F/53C	156.7L
27R	01*	OFF	84.3	157	159	159	127F/53C	156.7L
27LX	01*	OFF	85.0	155	159	159	120F/49C	156.7L
35	01*	ON	87.0	135	142	145	MAX-IMP	156.7L
27LS	01	OFF	84.3	157	159	159	127F/53C	156.7L

7.0 Meteorological Information[43]

Airport surface wind observations from PHL were obtained from the National Weather Service. Airport wind information found in the Aviation Routine Weather Reports (METARs)[44] for PHL originated from an Automated Surface Observing System (ASOS), but these reports could have been augmented by the local Certified Weather Observer. The following METARs were issued for PHL for the time period surrounding the accident:

[41] Source: USAirways A319/320/321 PH, Section 5.5 TPS Departure Plan Description.
[42] Source: USAirways.
[43] Meteorological information for this accident was provided and reviewed by Mr. Mike Richards, Aviation Safety Investigator - Senior Meteorologist, NTSB.
[44] Aviation routine weather reports (METAR) are taken manually by NWS, FAA, contractors, or supplemental observers. METAR reports are also provided by Automated Weather Observing System (AWOS), Automated Surface Observing System (ASOS), and Automated Weather Sensor System (AWSS). Source: AIM 7-1-1.

[1554 EDT] KPHL 131954Z 29018G27KT 10SM FEW070 01/M19 A2985 RMK AO2 PK WND 31037/1940 SLP108 T00061194=

[1654 EDT] KPHL 132054Z 30021G34KT 10SM FEW075 00/M20 A2988 RMK AO2 PK WND 30034/2048 SLP118 T00001200 53024=

[1754 EDT] KPHL 132154Z 29018G28KT 10SM CLR 00/M21 A2992 RMK AO2 PK WND 30033/2113 SLP130 T00001206=

Accident occurred at 2224Z (1824 EDT).

[1854 EDT] KPHL 132254Z 30012G19KT 10SM CLR 00/M21 A2997 RMK AO2 PK WND 29032/2205 SLP147 T00001206=

[1954 EDT] KPHL 132354Z 29016G22KT 10SM CLR M01/M21 A3002 RMK AO2 PK WND 29027/2311 SLP164 T10061211 10006 21011 53045=

At 1754, PHL reported a wind from 290° true at 18 knots with gusts to 28 knots, visibility of 10 miles or greater, clear skies, temperature 0° Celsius (C), dew point temperature -21°C, altimeter setting 29.92 inches of mercury. Remarks: station with a precipitation discriminator, peak wind of 33 knots from 300° occurred at 1713 EDT, sea-level pressure of 1013.0 hectopascals (hPa), hourly temperature of 0.0°C and hourly dew point temperature of -20.6°C.

At 1854, PHL reported a wind from 300° true at 12 knots with gusts to 19 knots, visibility of 10 miles or greater, clear skies, temperature 0°C, dew point temperature -21°C, altimeter setting 29.97 inches of mercury. Remarks: station with a precipitation discriminator, peak wind of 32 knots from 290° occurred at 1805 EDT, sea-level pressure of 1014.7 hPa, hourly temperature of 0.0°C and hourly dew point temperature of -20.6°C.

The ASOS[45] at PHL also recorded wind observations every minute. The following one-minute ASOS wind observations were retrieved for the time period surrounding the accident, where "Avg" indicates a 2-minute averaged quantity, "Gust" indicates a 5-second averaged quantity, directions are referenced to true north and magnitudes are in knots.

Station	Date	Time (UTC)	Avg Dir	Avg Mag	Gust Dir	Gust Mag
PHL	20140313	2215	311°	22	305°	25
PHL	20140313	2216	304°	19	310°	21
PHL	20140313	2217	303°	17	302°	19
PHL	20140313	2218	302°	18	320°	28
PHL	20140313	2219	301°	21	295°	27
PHL	20140313	2220	301°	24	293°	31
PHL	20140313	2221	299°	23	294°	25
PHL	20140313	2222	299°	20	322°	24
PHL	20140313	2223	297°	20	309°	24
PHL	20140313	2224	292°	20	302°	25

[45] Automated Surface Observing System (ASOS). For additional information on ASOS, see the Aeronautical Information Manual (AIM), page 7-1-1.

PHL	20140313	2225	303°	19	318°	29
PHL	20140313	2226	306°	20	308°	27
PHL	20140313	2227	302°	21	300°	26
PHL	20140313	2228	299°	21	294°	27
PHL	20140313	2229	294°	19	297°	21
PHL	20140313	2230	296°	19	281°	24

Screenshots of the Integrated Terminal Weather System (ITWS) Situation Display for PHL were retrieved from the Federal Aviation Administration. These images depict weather radar data and certain meteorological hazard (e.g. microburst and windshear) alerts for the region (none were active), as well as wind information presented on the Ribbon Display Terminal (RBDT) in the PHL air traffic control tower. The RBDT for PHL provides a parameter called the *airport wind* (AW), which is a wind observation likely retrieved from the Wind Measuring Equipment sensor located at PHL, and is referenced to magnetic north (directions rounded to nearest 10°) with magnitudes in knots. Images depicting ITWS Situation Display data for a time period surrounding the accident may be found in figures 1-4. The AW, which may be found in the window labelled "PHL – RIBBON DISPLAY ALERTS" in these images, was as follows:

Time(UTC)	Airport Wind
2222:54	310° at 19 knots, gusts to 29 knots
2223:34	310° at 19 knots
2224:35	320° at 20 knots
2225:35	320° at 19 knots

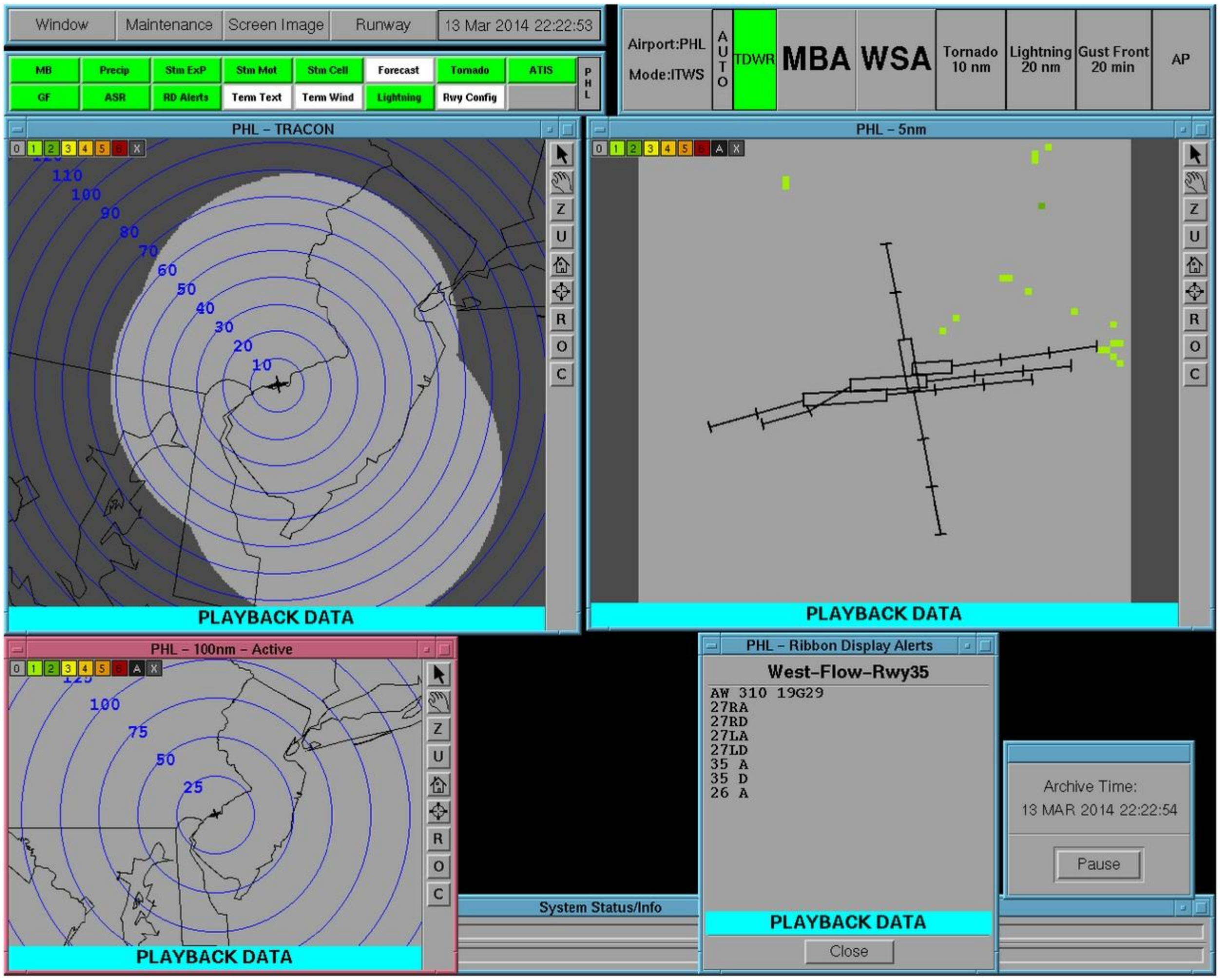

Figure 1: ITWS Situation Display screenshot for 2222:54 UTC.

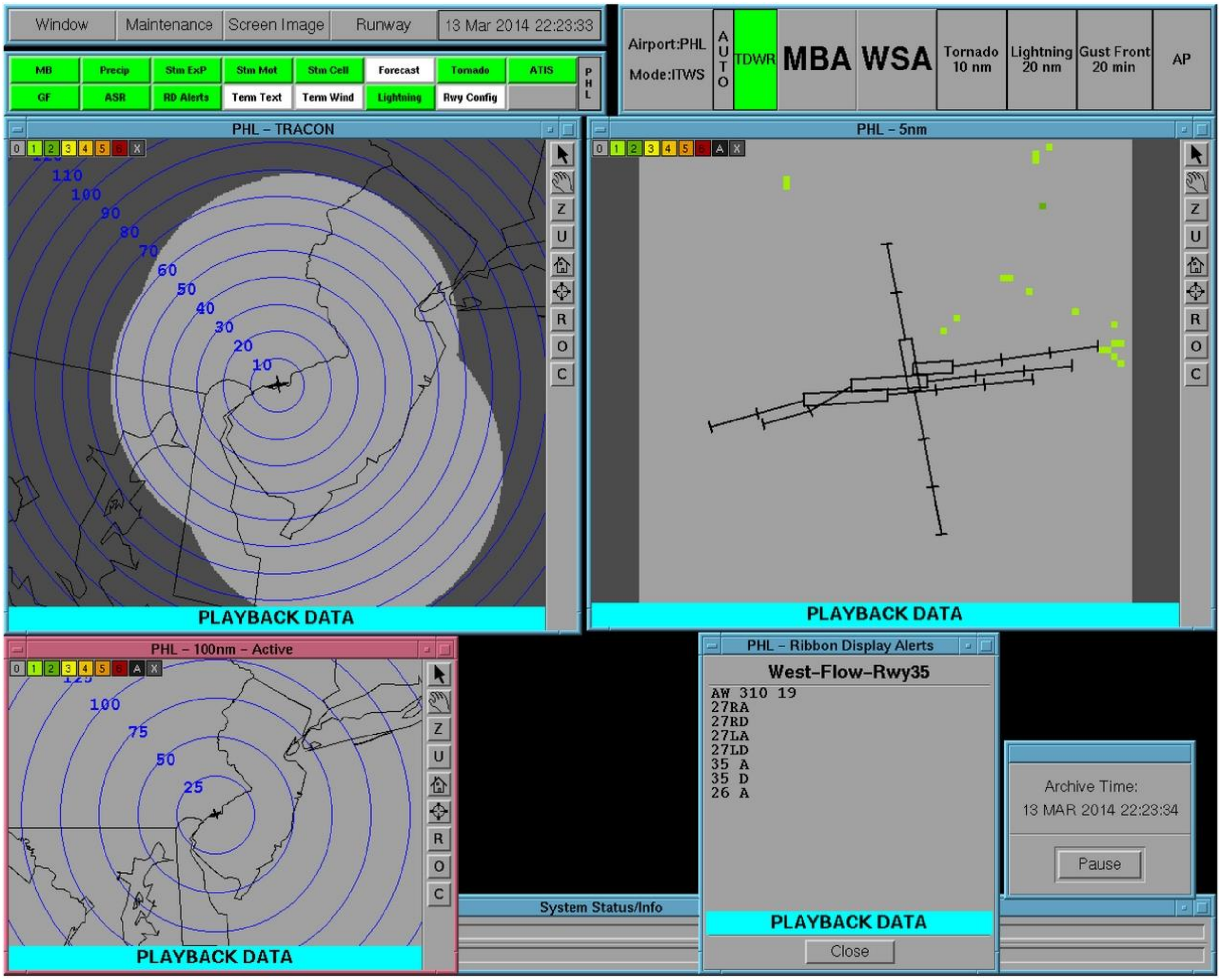

Figure 2: ITWS Situation Display screenshot for 2223:34 UTC.

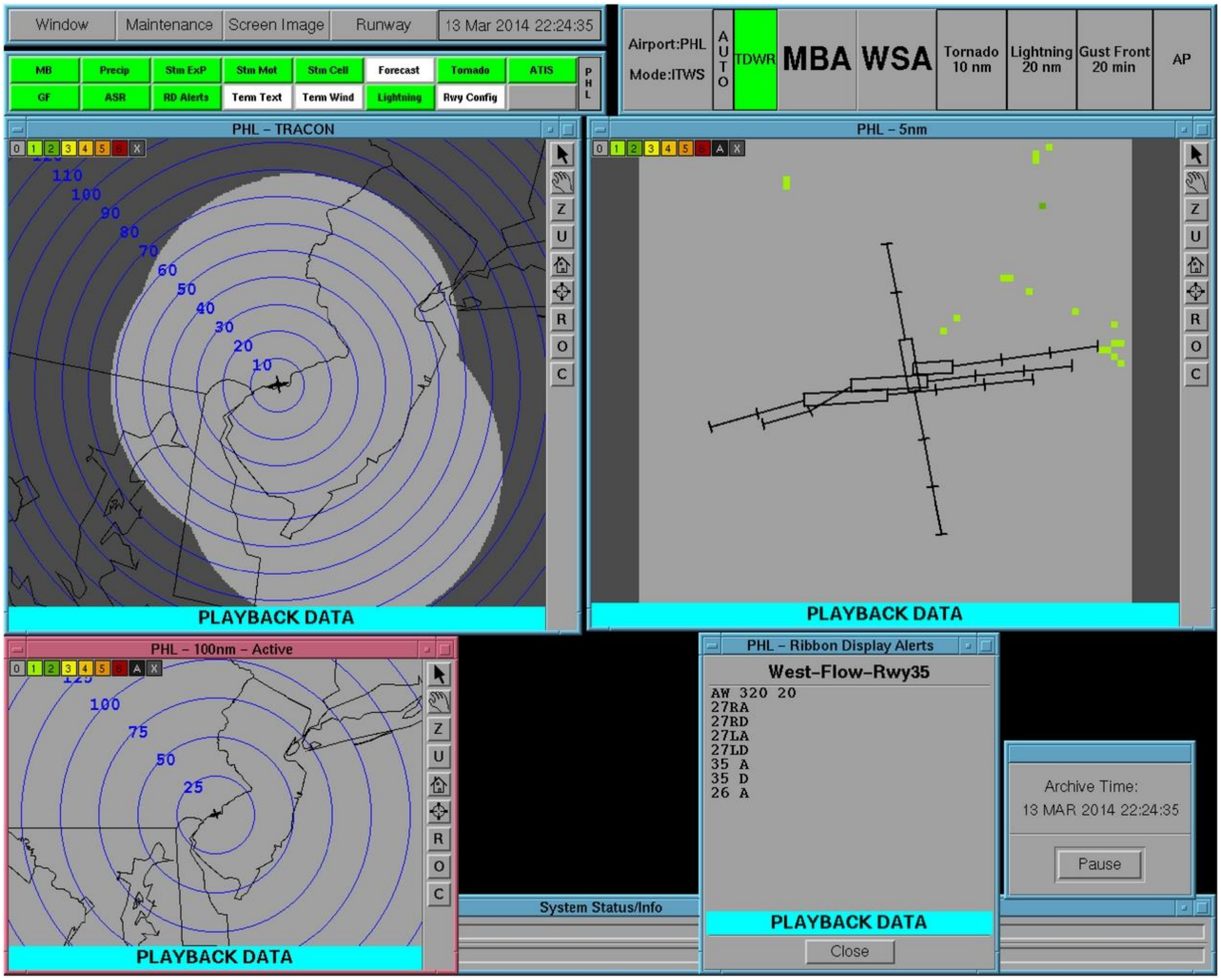

Figure 3: ITWS Situation Display screenshot for 2224:35 UTC.

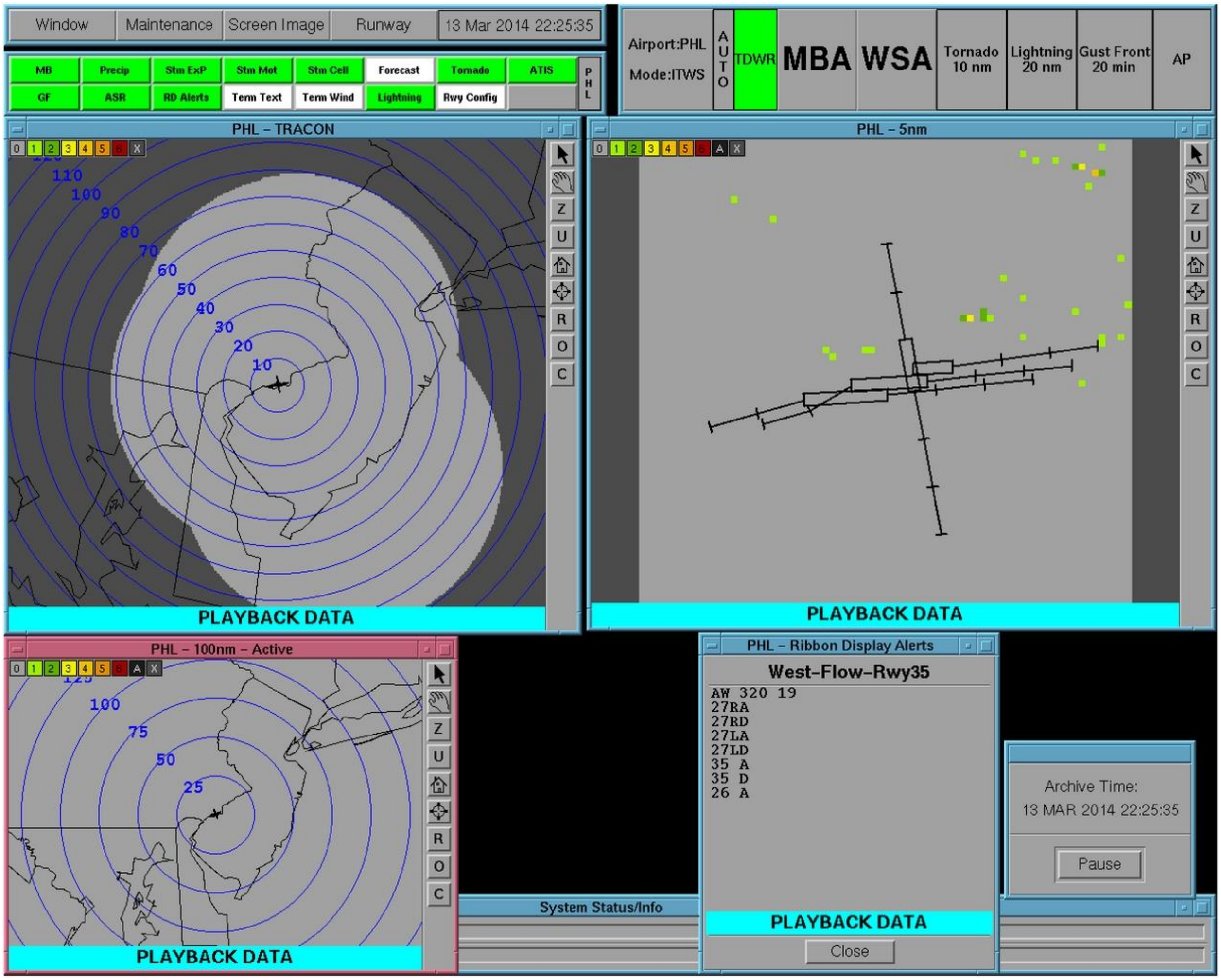

Figure 4: ITWS Situation Display screenshot for 2225:35 UTC.

According to the USAirways A319/320/321 PH, Section 1.3.1 Operational Limits, the maximum 90° crosswwind component for takeoff and landing was 29 knots with gusts to 35 knots. The USAirways A319/320/321 PH included a footnote that stated "maximum crosswind values have been demonstrated with flight controls in normal law as well as direct law with and without yaw damper."[46]

8.0 Aids to Navigation

Not applicable.

9.0 Communications

There were no known communication difficulties.

[46] Source: USAirways A319/320/321 PH, Section 1.3.1 Operational Limits.

10.0 Air Traffic Control[47]

According to ATC transcripts, at 1808:20 AWE1702 contacted the PHL ATC ground controller at “spot two” for taxi clearance, and at 1808:25, the ground controller responded “cactus seventeen zero two philly ground runway two seven left [runway 27L] taxi via yankee hold short of the nine left approach.” According to crew interviews, both of the accident pilots were expecting 27L for departure.

AWE1702 had a scheduled departure time of 1750. ATC gave AWE1702 an EDCT of 1829 (2229Z). The accident occurred at about 1824.

Figure 5: ATC Flight Progress Strip.[48]

For more information regarding Air Traffic Control related to the accident flight, see Attachment 5 – Air Traffic Control.

11.0 Airport Information (Philadelphia International Airport – PHL) [49]

Philadelphia International Airport was located 5 miles southwest of Philadelphia, Pennsylvania at a field elevation of 36.1 feet above mean sea level (msl) and at a latitude/longitude of N39º 52.3´/W075º 14.5´. The airport had a continuously operated FAA Control Tower.

[47] ATC information related to the accident flight was requested and reviewed by Mr. Brian Soper, Senior Air Traffic Investigator, NTSB.
[48] Source: FAA. For additional ATC information, see Attachment 5 – Air Traffic Control.
[49] Airport information was obtained from the Federal Aviation Administration’s National Aeronautical Charting Office (NACO) Terminal Procedures Publication (TPP) and Airport Facility Directory (AFD).

11.1 Runway Information

PHL was served by multiple runways. The east/west runway configuration consisted of two parallel runways: 09R/27L and 09L/27R. During crew interviews with NTSB staff, both pilots indicated that they received their taxi and takeoff clearance for runway 27L, however, the FO originally inserted 27R into the computer as the departure runway prior to taxi.

11.1.1 Runway 27L

Runway 27L, which was 10,506 feet long and 200 feet wide, had an asphalt grooved surface, and was in good condition. The entire length of the runway was available for takeoff and landing performance calculations. The runway had a 0.1% gradient, and high intensity runway edge lights and centerline lighting.

11.1.2 Runway 27R

Runway 27 R, which was 9,500 feet long and 150 feet wide, had an asphalt grooved surface, and was in good condition. The entire length of the runway was available for takeoff and landing performance calculations. The runway had a 0.1% gradient, and high intensity runway edge lights and centerline lighting.

11.1.3 Airport Chart

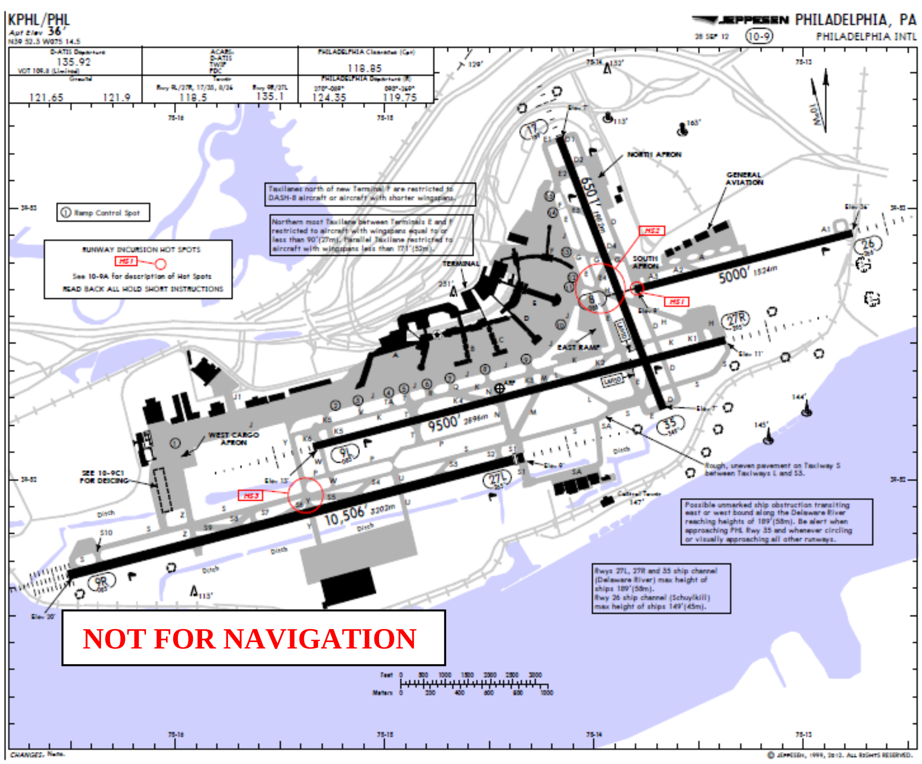

Figure 6: Jeppesen PHL 10-9 airport chart.[50]

[50] Source: Jeppesen.

12.0 Operator Information

12.1 Company Overview[51]

USAirways started in 1939 as All-American Airways delivering air-mail to Western Pennsylvania and the Ohio Valley using single engine Stinson Reliant aircraft. All-American Airways grew into Allegheny Airlines, US Air and finally US Airways after buy outs and mergers. On December 9, 2013 AMR Corporation, the parent company of American Airlines, and US Airways Group, the parent company of US Airways merged. The combined airlines were owned by American Airlines Group, Inc. a publicly traded airline holding company headquartered in Fort Worth, Texas. The airline groups together formed the largest airline in the world, with more than 6,700 daily flights to 336 locations in 56 countries worldwide, about $40 billion in operating revenue, over 100,000 employees, and plans to take delivery of 607 new aircraft, including 517 narrow body aircraft and 90 wide body international aircraft. The integration of American Airlines and USAirways under a single operating certificate was expected to be completed in late 2015.

USAirways held an Air Carrier Certificate (Number USAA105A) and was authorized to conduct domestic and flag operations.

As of December 31, 2013, USAirways operated 93 A319s, 70 A320s, 91 A321s, 12 A330-200s, 9 A330-300s, 14 B737-400s, 24 B757-200s, 10 B767-200ERs and 20 ERJ 190s, of which 123 are owned and 220 are leased.[52]

As of December 31, 2013, USAirways had 4,100 pilots (2,800 USAirways pilots and 1,300 America West pilots) represented by the US Airline Pilots Association (USAPA). Pilots at USAirways were covered under the Aviation Safety Action Program (ASAP).[53]

12.2 Training

USAirways A320 pilot training was conducted under Advanced Qualification Program (AQP).[54] According to the USAirways Director of Flight Training and Standards, the Flight Data Analysis

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[51] Source: American Airlines Group 10-K Annual Report for the Fiscal Year Ended December 31, 2013 (http://phx.corporate-ir.net/phoenix.zhtml?c=117098&p=irol-sec).

[52] Source: American Airlines Group 10-K Annual Report for the Fiscal Year Ended December 31, 2013 (http://phx.corporate-ir.net/phoenix.zhtml?c=117098&p=irol-sec).

[53] According to the FAA Advisory Circular 120-66B Aviation Safety Action Program (ASAP), the objective of the ASAP is to encourage air carrier and repair station employees to voluntarily report safety information that may be critical to identifying potential precursors to accidents. The Federal Aviation Administration (FAA) has determined that identifying these precursors is essential to further reducing the already low accident rate. Under an ASAP, safety issues are resolved through corrective action rather than through punishment or discipline. The ASAP provides for the collection, analysis, and retention of the safety data that is obtained. ASAP safety data, much of which would otherwise be unobtainable, is used to develop corrective actions for identified safety concerns, and to educate the appropriate parties to prevent a reoccurrence of the same type of safety event.

[54] The Advanced Qualification Program (AQP) is a voluntary alternative to the traditional regulatory requirements under CFR 14, Parts 121 and 135 for pilot training and checking. Under the AQP the FAA is authorized to approve significant departures from traditional requirements, subject to justification of an equivalent or better level of safety. The program entails a systematic front-end analysis of training requirements from which explicit proficiency

Group (FDAG)[55] looked at data from Flight Operational Quality Assurance (FOQA), ASAP, training from line events and AQP events, and the training proficiency database. That group made recommendations or risk mitigations to issues they tracked on a watch list or concerns list. Recommendations could be to policies and procedures or to training. At the end of each AQP cycle, the group made recommendations for the next cycle's training objectives.

Pilots were taught a "CAMI" procedure for automation input and monitoring. The USAirways A320 PH, Section 2.9.3 CAMI Procedure, defined the "CAMI" procedure as:

> ***C****onfirm FMS [flight management system] inputs with the other pilot when airborne.*
> ***A****ctivate the input.*
> ***M****onitor mode annunciations to ensure autoflight system performs as desired, and*
> ***I****ntervene if necessary*.

12.3 Flight Safety

According to the USAirways FOM, Section 1.2.2, Flight Safety, the department responsibilities included:

> *— Communicating safety information to dispatchers, flight attendants, and pilots.*
> *— Day-to-day oversight of flight operations to ensure the highest levels of safety are maintained.*
> *— Ensuring all flight operational policies and procedures are developed and implemented with safety being the primary concern.*
> *— Proactively identifying and mitigating safety hazards.*
> *— Investigating incidents and accidents and recommending corrective actions for prevention purposes.*
> *— The collection and analysis of safety data from Event Reporting, Aviation Safety Action Program (ASAP), Flight Operations Quality Assurance (FOQA) Program, and the Line Operations Safety Audit (LOSA).*

According to the Vice President of Safety, Security and Environmental for American Airlines, based on their data, they had not seen any trends on the number of rejects associated with the A320. He stated that in 2013 they had a rejected takeoff due to the "same situation as AWE1702," and the crew got the "retard" alert and decided to reject the takeoff.[56] The ASAP group talked to the pilots and found out that they did not have an assumed temperature in the FMC, and when they got the "THRUST NOT SET" ECAM, they did not put the thrust levers to

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objectives for all facets of pilot training are derived. It seeks to integrate the training and evaluation of cognitive skills at each stage of a curriculum. For pass/fail purposes, pilots must demonstrate proficiency in scenarios that test both technical and crew resource management skills together. Air carriers participating in the AQP must design and implement data collection strategies which are diagnostic of cognitive and technical skills. In addition, they must implement procedures for refining curricula content based on quality control data. (Source: FAA). See AC 120-54A Advanced Qualification Program.

[55] For additional information on FDAG, see Section 15.9.3.1 Flight Operations Standards Board (FOSB) of this Factual Report.

[56] The NTSB could not verify the circumstances of this 2013 event.

TOGA.[57] The USAirways Safety Department distributed a notice to the pilots informing them of the event and that the crew got the "retard" aural alert. The information on that event was shared in June 2013. He did not know if there was any conversation with Airbus following that event.[58]

He said for the "Retard" aural alert on takeoff, following the flight 1702 accident Safety did a study for the first 3 months of the year and found that there were three other occasions when the "Retard" alert may have come on based on a look at various variables associated with the airplane's logic. The only occurrence that they knew for sure the "Retard" alert came on was the event from last year.

There were two messages that went out last year following the rejected takeoff event; one was a message from Flight Standards and Training, and the other one was from the Safety department.[59]

13.0 Pilot Reference Manuals

USAirways pilots and dispatchers were responsible for knowing and complying with information contained in Flight Operations Manuals.[60]

The USAirways Flight Operations Manual (FOM), dated September 13, 2013, provided policy and procedural guidance based on Flight Operations philosophy and was required to be carried in flight. The following sections/paragraphs of the FOM required FAA approval, and must be processed through the FAA "Approved Manual" procedures:[61]

— Paragraph 1.4.4 Part 121 Extended Over-Water Operations Without Certain Emergency Equipment
— Section 6.1 Takeoff Weight and Balance
— Section 7.7 Aircraft Icing and De/Anti-Icing Program
— Chapter 9: Flightdeck Jumpseat
— Paragraph 11.1.1 Special Airport Qualification

The USAirways A319/320/321 Pilot Handbook (PH), dated July 19, 2013, was one of USAirways operating manuals that could be substituted for the FAA-approved Airplane Flight Manual as provided by FAR 121.141. The USAirways A319/320/321 PH was an FAA approved manual. The A319/320/321 Pilot Handbook provided guidance to flight personnel regarding the A319/320/321 aircraft in flight operations and was required to be carried in flight.[62] Further, the USAirways A319/320/321 PH, Pre-ii, stated the following:

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[57] Takeoff/Go-around thrust setting.
[58] Airbus provided the following comment to the NTSB in February 2015: "Airbus communicated with AWE / USA when the 4 occurrences anterior to June 2009 were reported. A detailed analysis of the event was provided. Airbus did not receive any report between June 2009 and the date of occurrence."
[59] See Attachment 1 – Interview Summaries. For more information on company correspondence on the "Retard" alert, see Section 15.9.3 "Retard" Aural Alert on Takeoff, of this Factual Report.
[60] Source: USAirways Flight Operations Manual, Preface-1.
[61] For further information, see FAA 8900.1 Volume 3, Chapter 32, Section 2 Approval and Acceptance of Manuals and Checklists.
[62] Source: USAirways A319/320/321 PH, Preface, page Pre-ii. The A319/320/321 PH included the following

Flight personnel are responsible for knowing and complying with information contained within this Pilot Handbook. Deviations may occur; however, individuals will be held accountable for their actions/non-actions.

The A319/320/321 QRH, dated August 16, 2013, provided aircraft specific non-normal/quickly referenced information and was required to be carried in flight.

The USAirways A319/320/321 Training Manual (TM), dated July 10, 2013, supplemented the A319/320/321 Pilot Handbook and contained information such as aircraft & systems descriptions, expanded explanation of procedures, and other selected pertinent topics applicable to the A319/320/321 aircraft. The A319/320/321 TM was one of US Airways supplemental manuals and was an FAA accepted manual.

According to the USAirways FOM, Section 1.1.3 Operations Specifications, the Flight Operations Standards Board (FOSB) incorporated the Operations Specifications directly into the policies and procedures of the USAirways flight documents (FOM, Pilot Handbook, QRH, etc.). Compliance with these policies and procedures met all pilot requirements of the FAA-authorized Operations Specifications.

14.0 Relevant Systems

14.1 Flight Controls[63]

The flight control surfaces were electrically-controlled and hydraulically actuated by three independent hydraulic systems. The stabilizer and rudder could be mechanically controlled and hydraulically actuated. Pilot inputs were provided through sidesticks and rudder pedals. There was a speedbrake lever, two mechanical pitch trim wheels, and an electrical rudder trim switch. The sidesticks provided electrical signals to the flight control computers for pitch and roll control. The sidesticks operated independently of each other. They did not move with autopilot or opposite sidestick inputs. They had artificial feel and were spring-loaded to neutral. If both sidesticks were operated simultaneously both inputs were algebraically added. A takeover pushbutton enabled a pilot to deactivate the other sidestick.

There were seven flight control computers which process pilot and autopilot (AP) inputs. In normal law the computers prevented excessive maneuvers and flight outside the safe flight envelope in pitch and roll axes. The flight crew controlled the rudder via a mechanical rudder control. Rudder travel limitation was provided without enhanced yaw envelope protection. The flight control computers were: two elevator aileron computers (ELAC) for normal elevator, stabilizer and aileron control; three spoiler elevator computers (SEC) for spoiler control plus

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statement: "Certain changes to the manufacturer's recommendations in operating technique and procedures have been made. These differences have been found by US Airways as a result of experience to be in consonance with and in the best interest of safety and good operating practice. Where the procedures in this manual differ from those in the FAA-Approved Airplane Flight Manual, US Airways has determined that equivalent safety is provided by such alternate procedures and assumes full responsibility for this determination. Flight crewmembers are expected to utilize the operating techniques and procedures outlined in this Pilot Handbook."

[63] Source: USAirways A319/320/321 TM, Section 9.1 System Description.

standby elevator and stabilizer control; two flight augmentation computers (FAC) for rudder control. Two Flight Control Data Concentrators (FCDC) processed information from the ELACs and SECs and sent data to the Electronic Instrument System (EIS) and Centralized Fault Display System (CFDS).

14.2 Flight Control Laws[64]

There were three primary flight control laws for the A320: Normal, Alternate, and Direct.

14.2.1 Normal Law.

Normal law was the normal operating configuration of the system. Failure of any single computer did not affect normal law. Normal law had three modes according to the phase of flight; ground, flight and flare.

Ground Mode: Ground mode was active when the aircraft was on the ground. This mode was a direct relationship between sidestick deflection and deflection of the flight controls. This mode was active until shortly after liftoff and after touchdown.

Flight Mode: The flight mode became active after takeoff and remained active until shortly before touchdown. Sidestick pitch input commanded a load factor proportional to stick deflection and independent of speed. With the sidestick neutral at wings level the flight controls maintained a 1g load in pitch. The stabilizer was autotrimed to compensate for airspeed changes, configuration changes or bank up to 33°. With full aft or forward sidestick deflection the system would limit the maximum load factor.

Roll input on the sidestick commanded a roll rate independent of airspeed; a given sidestick deflection would result in the same roll rate response. Turn coordination and yaw damping were automatically computed. There was no rudder pedal movement for yaw damping and turn coordination.

Flare Mode: Transition to flare mode occurred at 50 feet radio altitude (RA) during landing. The system memorized the pitch attitude at 50 feet and then began to progressively reduce pitch causing the pilot to flare the aircraft. In the event of a go around, transition to flight mode occurred again at 50 feet RA.

Protections: Normal law protected the aircraft throughout the flight envelope as follows:

> — Load factor limitation prevented overstressing the aircraft even if full sidestick deflections were applied.
>
> — Attitude protection. Pitch was limited to 30° up, 15° down, and 67° of bank. These limits were indicated by green "=" signs on the PFD. Bank angles in excess of 33° required constant sidestick input. If the input was released the aircraft returned to and maintained 33° of bank.

[64] Source: USAirways A319/320/321 TM, Section 9.1.6 Flight Control Laws.

— High angle of attack protection. When the angle of attack exceeded alpha protection (α prot) ,[65] elevator control switched to α protection mode in which angle of attack was proportional to sidestick deflection. However α max[66] would not be exceeded even if the pilot applied full aft deflection. If the pilot released the sidestick to neutral the angle of attack returned to alpha protect.

— High speed protection prevented exceeding V_{MO} or M_{MO} (maximum operating speed) by introducing a pitch up load factor demand. The pilot could not override the pitch up command.

— Low energy warning. An aural "SPEED SPEED SPEED" would occur when a change in flight path alone was insufficient to regain a positive flight path. (Available in Flap CONF 2, 3, or FULL, between 100' and 2,000' RA and not in TOGA.)

14.2.2 Alternate Law

If multiple system failures occurred, the flight controls reverted to alternate law. There were many different combinations of alternate flight control laws. The ECAM displayed the message "ALTN LAW: PROT LOST." Depending on the specific failure the autopilot may be available.

Ground Mode: The ground mode was identical to normal law.

Flight Mode: In pitch alternate law the flight mode was a load factor demand law similar to the normal law flight mode with reduced protections. In alternate law, automatic pitch trim was available and yaw damping (with limited authority) was available. Turn coordination was lost. There was no roll alternate law. Pitch law degraded from normal law and roll degrades into direct law. In this case roll rate depended on airspeed.

Protections: All protections except for load factor maneuvering protection were lost. Amber "X"s replaced the green "=" attitude limits on the PFD. A low speed stability function replaced the normal angle-of-attack protection. The system introduced a progressive nose-down command which attempted to keep the speed from slowing further. This command could be overridden by sidestick input. The airplane could be stalled in alternate law. An audio stall warning consisting of "crickets" and a "STALL" aural message was activated. The α floor function was inoperative. A nose-up command was introduced any time the airplane exceeded V_{MO}/M_{MO} to keep the speed from increasing further. This command could be overridden by sidestick input. Bank angle protection was lost. Some failures caused the system to revert to alternate law without speed stability. Only load factor protection was provided. In alternate law the PFD airspeed scale was modified. While V_{LS} remained displayed, Vα prot and Vα max

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[65] α PROT or Alpha Protection Speed is indicated by the top of the black and amber strip along the speed scale. It represents the speed corresponding to the angle of attack at which alpha protection becomes active. It is only displayed in normal law.

[66] α MAX or Alpha Max is the top of the solid red strip along the speed scale. It represents the speed corresponding to the maximum angle of attack that the aircraft can obtain in normal law.

were removed. They were replaced by a red and black barber pole. The top of the pole indicated the stall warning speed (Vsw)[67].

14.2.3 Direct Law

Direct law was the lowest level of computer flight control resulting from multiple failures. Pilot control inputs were transmitted unmodified in a direct relationship between sidestick and control surface. Control sensitivity depended on airspeed and no auto-trimming was available. An amber message "USE MAN PITCH TRIM" appeared on the PFD. Alternate law degraded to direct law automatically when the landing gear was extended when no autopilot was engaged. If an autopilot was engaged, the airplane would remain in alternate law until the autopilot was disconnected. There were no protections in direct law; but, overspeed and stall aural warnings were provided. The PFD airspeed scale remained the same as in alternate law.

14.3 Thrust Control[68]

On the A319/320321, the pilot used the thrust levers to do the following:

— manually select engine thrust
— arm and activate A/THR
— engage reverse thrust
— engage the takeoff and go around (TOGA) modes

Five detents divided each of the thrust lever sectors into four segments. The detents were:

TO GA:	Max takeoff thrust
FLX MCT:	Max continuous thrust (or FLX at takeoff)
CL:	Maximum climb thrust
IDLE:	Idle thrust for both forward and reverse thrust
IDLE REV:	Idle reverse thrust
MAX REV:	Maximum reverse thrust

When the thrust levers were at the IDLE position, the pilot could pull them up to clear the IDLE stop and select reverse thrust.

The thrust lever angle (TLA) was electronically measured and sent to the FADEC to compute the thrust rating limit. There was no mechanical connection between the thrust levers and the engines.

Each detent represented an upper thrust limit. If thrust lever was set between two detents, the FADEC selected the rating limit for the higher detent. The thrust limit was displayed on the upper ECAM.

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[67] Vsw or Stall Warning Speed is the top of the red and black strip along the speed scale. It is the speed corresponding to the stall warning. It is displayed when operating in other than normal law.
[68] Source: USAirways A319/320/321 TM, Section 17.2.1 Thrust Levers, and Section 17.1.4 Thrust Control.

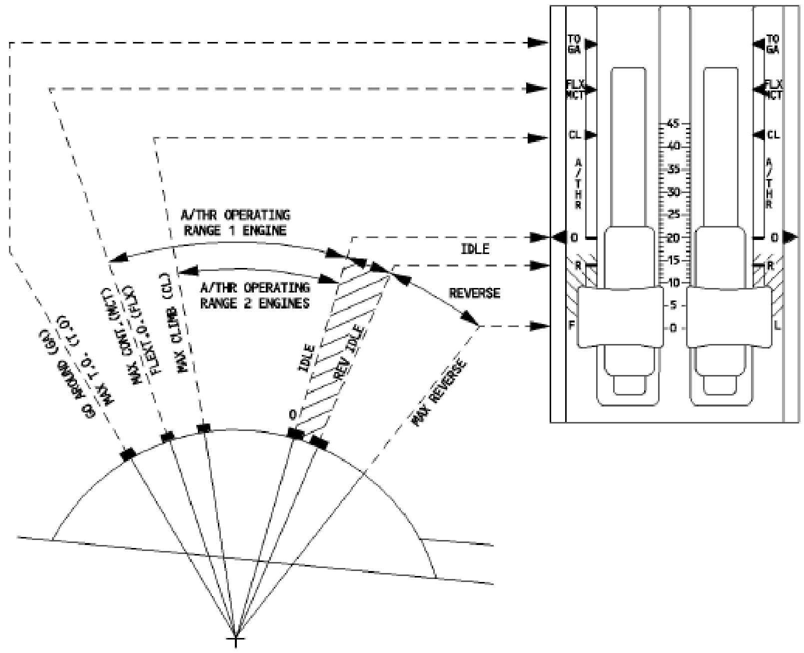

Figure 7: A320 Thrust Lever Positions.[69]

With the thrust lever in the FLX/MCT detent:

— On the ground: The engine ran at the FLEX takeoff thrust rating if the crew had selected a FLEX takeoff temperature on the MCDU that was higher than the current TAT. Otherwise the engine produced Maximum Continuous Thrust (MCT). A change in FLEX TEMP during the takeoff had no effect on thrust.

— After takeoff: The pilot would move the thrust levers to TOGA or CL then back to MCT to change FLX to MCT.

14.4 Electronic Flight Instrument System (EFIS)[70]

The electronic flight instrument system presents data on six identical Display Units (DU):

— The Electronic Flight instrument System (EFIS) displayed mostly flight parameters and navigation data on the Primary Flight Displays (PFD) and Navigation Displays (ND).

— The Electronic Centralized Aircraft Monitor (ECAM) presented data on the Engine/Warning Display (E/WD) and System Display (SD), including the following:

- primary engine indications, fuel quantity, flap and slat position
- warning and caution alerts or memos
- synoptic diagrams of aircraft systems and status messages

[69] Source: USAirways A319/320/321 TM, Section 17.1.4 Thrust Control.
[70] Source: USAirways A319/320/321 TM, Section 10.1 System Description.

• permanent flight data

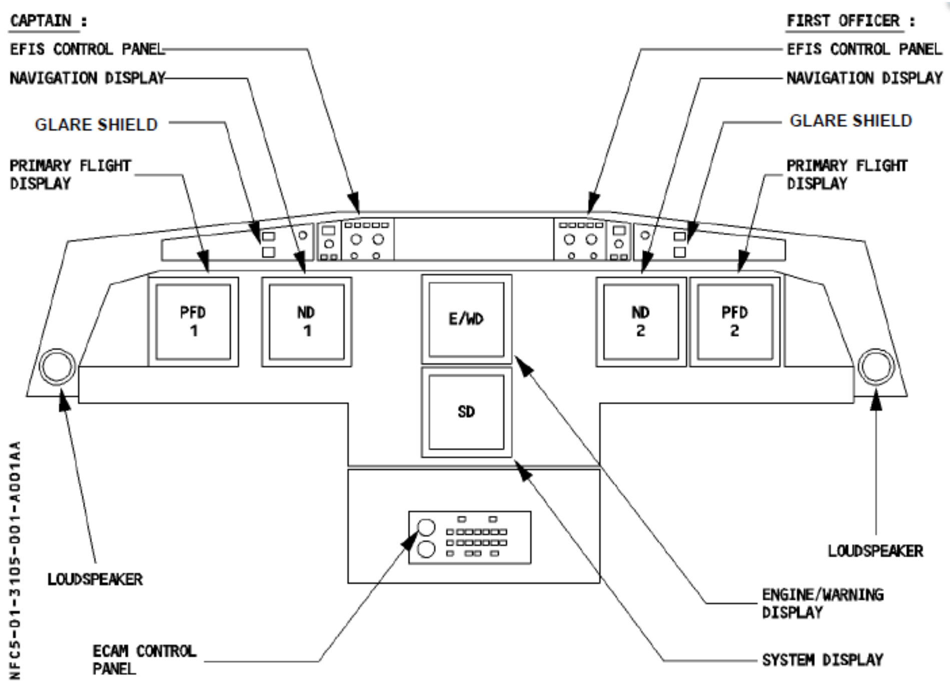

Figure 8: A320 Cockpit EFIS System.[71]

14.4.1 Primary Flight Displays (PFD)[72]

Each PFD integrated several conventional flight instrument presentations on one display. The displayed information were:

— attitude indication
— FD commands
— localizer, glideslope, and VNAV deviation indications
— airspeed
— vertical speed
— barometric altitude
— radio altitude
— heading/track information
— FMGS[73] modes (FMA)
— altimeter setting
— ILS identifier
— marker beacons

[71] Source: USAirways A319/320/321 TM, Section 10.1 System Description.
[72] Source: USAirways A319/320/321 TM, Section 10.1.3 Primary Flight Displays (PFD).
[73] Flight Management Guidance Envelope System. The USAirways A319/320/321 TM, Section 5.1.1 General, stated: "The Flight Management Guidance System (FMGS) is an interactive system providing Flight Management function and Flight Guidance control. The system generates vertical and lateral flight profiles and predicted progress along the entire flight path. The FMGS reduces flight deck workload and increases efficiency by eliminating many routine tasks and computations normally performed by the crew.

— TCAS and windshear recovery commands
— Backup Speed Scale and Altitude Scales (as installed)

14.4.1.1 PFD Speed Indications

Airspeed was depicted on the left scale of the PFD.

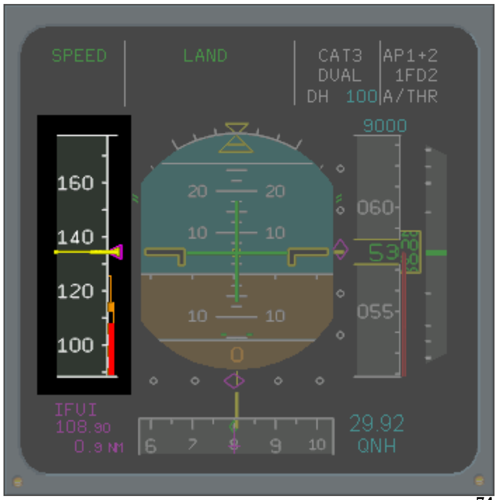

Figure 9: Airspeed indicator on the PFD. [74]

Decision speed (V_1) was displayed by a blue number one on the speed scale from the speed that was entered into the MCDU. If the decision speed was off scale the numeric value would be displayed in blue near the top of the airspeed indicator.

Takeoff safety speed (V_2) was displayed during takeoff by a magenta triangle on the speed scale from the speed that was entered into the MCDU. If V_2 is off scale the numeric value would be displayed in magenta at the top of the airspeed indicator.

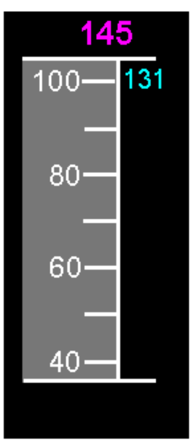

Figure 10: V_1/V_2 speed indication. [75]

[74] Source: USAirways A319/320/321 TM, Section 10.2.5 Indications on PFD.
[75] Source: USAirways A319/320/321 TM, Section 10.2.5 Indications on PFD.

14.4.2 Navigation Display (ND)[76]

Each ND displayed the following navigational information:

— navigation waypoints
— track
— ground speed
— radio nav identifiers, frequencies, and location
— true airspeed
— chronometer time
— EGPWS terrain
— TCAS
— weather radar
— predictive windshear (as installed)
— vertical and horizontal navigational constraints

14.5 Flight Mode Annunciator

The Flight Mode Annunciator (FMA) was located at the top of each PFD, and showed the status of the A/THR (auto thrust), the AP/FD (auto pilot/flight director) vertical and lateral modes, the approach capabilities, and the AP/FD-A/THR engagement status.[77] After each mode change, the FMA displayed a white box around the new annunciation for ten seconds. The white box display time may be increased to 15 seconds for mode reversions associated with a triple click.[78]

Figure 11: A320 Flight Mode Annunciator.[79]

14.6 Electronic Centralized Aircraft Monitoring (ECAM)[80]

The ECAM was a computer network which processed and displayed engine and system parameters, fault monitoring and corrective procedures on two identical center instrument panel screens. The primary components of the ECAM were two System Data Acquisition Concentrators (SDACs) and two Flight Warning Computers (FWCs).

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[76] Source: USAirways A319/320/321 TM, Section 15.1.2 Navigation Displays.
[77] Source: Airbus A318/A319/A320/A321 Flight Crew Operating Manual, FMA, page 1/12 (provided to the NTSB by Airbus).
[78] Source: USAirways A319/320/321 TM, Section 5.2.3 Flight Mode Annunciator (FMA).
[79] Source: USAirways A319/320/321 TM, Section 5.2.3 Flight Mode Annunciator (FMA).
[80] Source: USAirways A319/320/321 TM, Section 10.1.4 Electronic Centralized Aircraft Monitoring (ECAM).

The Electronic Centralized Aircraft Monitor (ECAM) presented data on the Engine/Warning Display (E/WD) on the upper ECAM display, and System Display (SD) on the lower ECAM display, including:

- Primary engine indications, fuel quantity, flap and slat position
- Warning and caution alerts, or memos
- Synoptic diagrams of aircraft systems, and status messages
- Permanent flight data

14.6.1 ECAM Indications

According to the USAirways A320 PH, Section 10.1.4 Electronic Centralized Aircraft Monitoring (ECAM), when a malfunction was detected, the following occurred:

> *— The title of the malfunction is displayed on the left lower quadrant of the E/WD. The name of the affected system is underlined. Boxed items indicate primary malfunctions.*
> *— The actions to be taken are displayed below the title.*
> *— Other systems affected by the malfunction are shown on the right lower quadrant of the E/WD. An asterisk (*)indicates secondary malfunctions.*
> *— The affected system page is displayed on the SD.*
> *— The CLR pb is illuminated on the ECP.*
> *— A local warning light associated with the affected system is illuminated.*

If there was additional data that could not be displayed in the limited screen space, a green overflow arrow at the bottom of the screen directed the crew to scroll down. Scrolling was accomplished by pressing the CLR (clear) pushbutton (pb). As the crew completed each action, the step cleared from the screen. Actions that could not be monitored by the FWCs, did not automatically clear from the screen. At the end of the procedure, pressing the CLR pb displayed the affected System page for review. When all affected Systems pages were cleared, the STATUS page was displayed.

A review of the ECAM abnormal procedure could be accomplished by pressing the RCL (recall) pb. If any actions were not accomplished previously, they would appear on the E/WD. If a system parameter exceeded its normal range, the system page was displayed on the SD and the parameter flashes in green.

14.6.2 Engine/Warning Display (E/WD)

The E/WD was divided into four sections and displayed the following: primary engine instruments, fuel quantity and flap/slat position, warnings and cautions, ECAM (memo) messages concerning airplane systems status.

14.6.3 ECAM Color Codes

The ECAM display units used a color code to indicate the importance of the failure or indication.

RED: Immediate action required
AMBER: Awareness but no immediate action required
GREEN: Normal operation
WHITE: Titles and remarks
BLUE: Actions to be carried out or limitations
MAGENTA: Special messages

14.6.4 ECAM Malfunction Notifications[81]

The ECAM provided three levels of notifications:

> Warnings: Associated with the red MASTER WARN light, red system limitations, and require immediate action.
>
> Cautions: Associated with the amber MASTER CAUT light, amber system limitations and require crew awareness, but not immediate action.
>
> Alerts: Associated with degraded systems advisories which are still within operating limitations.

In addition to the MASTER WARNING and MASTER CAUTION aural warnings, other aural warnings were: “WINDSHEAR”, “PRIORITY (L/R)”, “RETARD”, “SPEED, SPEED, SPEED”, and TCAS and EGPWS warnings. Although the altitude alert system provided an aural warning, the MASTER WARN light did not illuminate. The aural warning may still be cancelled by pressing either the MASTER WARN light or the EMER CANC push button.[82]

There were three priority levels for warnings and cautions: A level 3 warning had priority over a level 2 caution, which had priority over a level 1 caution. The FWC observed these priorities.[83]

14.6.5 ECAM Warning Inhibits[84]

During takeoff and landing, “T.O INHIBIT” or “LDG INHIBIT” memos were displayed in magenta to remind the crew that most of the failure titles and the associated checklists were suppressed. This prevented unnecessary distractions during critical phases of flight.

- Takeoff (T.O.) Memo: The T.O. memo appeared two minutes after the second engine was started or when the T.O. CONFIG TEST pb was pressed with one engine running. The memo was removed when takeoff power was applied.

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[81] Source: USAirways A319/320/321 TM, Section 10.1.4 Electronic Centralized Aircraft Monitoring (ECAM).
[82] For additional information, see Attachment 9 – A320 Aural Indications
[83] For levels of ECAM warnings and cautions, see Attachment 11 - ECAM Malfunction Notifications and Attachment 19 – A320 Warnings and Cautions.
[84] Source: USAirways A319/320/321 TM, Section 10.1.4 Electronic Centralized Aircraft Monitoring (ECAM).

- Landing (LDG) Memo: The LDG memo appeared below 2,000 feet RA with the landing gear down or below 800' RA with the landing gear up. (For aircraft with the new FWC, the LDG memo appeared below 2,000' RA regardless of landing gear position.). The memo disappeared after touchdown (80 knots).

14.7 Takeoff Configuration Warnings/Cautions

According to the USAirways A319/320/321 TM, Systems Description (Takeoff Configuration Warnings/Cautions), page 10-7, if the airplane was not properly configured for takeoff, the following warnings (red) and cautions (amber) were triggered when the T.O. CONFIG push button was pressed or when takeoff power was applied:

— *SLATS/FLAPS NOT IN T.O. RANGE*
— *PITCH TRIM NOT IN T.O. RANGE*
— *RUDDER TRIM NOT IN T.O. RANGE*
— *SPEED BRAKES NOT RETRACTED*
— *SIDESTICK FAULT*
— *HOT BRAKES*
— *DOOR NOT CLOSED (tested only if engines are operating)*

The following were only triggered when takeoff power was applied:

— *PARK BRAKE ON*
— *FLEX TEMP NOT SET (not displayed if thrust levers are set in the TOGA detent)*

According to the USAirways A319/320/321 TM, Systems Description (ECAM Indications) page 10-7, when a malfunction was detected, the following occurred:

— *The title of the malfunction is displayed on the left lower quadrant of the E/WD. The name of the affected system is underlined. Boxed items indicate primary malfunctions.*
— *The actions to be taken are displayed below the title.*
— *Other systems affected by the malfunction are shown on the right lower quadrant of the E/WD. An asterisk (*) indicates secondary malfunctions.*
— *The affected system page is displayed on the SD.*
— *The CLR pb [push button] is illuminated on the ECP.*
— *A local warning light associated with the affected system is illuminated.*

If there was additional data that could not be displayed in the limited screen space, a green overflow arrow at the bottom of the screen directs the crew to scroll down. Scrolling was accomplished by pressing the CLR push button. As the crew completed each action, the step cleared from the screen. Actions that could not be monitored by the FWCs, did not automatically clear from the screen. At the end of the procedure, pressing the CLR push button displayed the affected System page for review. When all affected Systems pages were cleared, the STATUS page was displayed.

A review of the ECAM abnormal procedure could be accomplished by pressing the RCL push button. If any actions were not accomplished previously, they would appear on the E/WD. If a system parameter exceeded its normal range, the system page was displayed on the SD and the parameter flashed in green.

14.8 Multipurpose Control and Display Unit (MCDU)[85]

There were two MCDUs on the flight deck. The MCDU was the long-term Flight Management control between the pilot and the FMS. The flight plan was inserted during preflight in terms of track, altitude and airspeed. The MCDU was then used to display, select, and modify data as required for flight management.

The MCDU Functions included:

— *Initial position to align the IRS before flight*
— *Primary, Secondary, and Alternate flight plans*
— *Weight, CG, fuel quantity for time and fuel predictions, and performance optimization*
— *Lateral and vertical revisions to the flight plan*
— *Auto-tuning or manually tuning navaids*
— *Navigation accuracy*
— *Pilot-defined navigation references*
— *Activating the Approach Phase*
— *Displaying data from other systems (ACARS, CFDS, AIDS)*

If MCDU input was not logical or outside the system capabilities, the entry would have no effect or generate an advisory message.

15.0 Relevant Procedures

15.1 Checklist Philosophy[86]

According to the USAirways PH, Section 2.3.1, Philosophy, the use of standardized procedures and terminology reduced confusion and promoted crew communication and understanding throughout the flight. The proper use of the Normal Procedures Flightdeck Checklist alleviated unsafe practices, carelessness, and the development of individualized procedures. The Checklist was the flight crew's safety net to help ensure all flows and procedures were accomplished correctly, and the checklist could only work effectively if it was accomplished properly.

15.1.1 Checklist Design

According to the USAirways A319/320/321 PH, Section 2.3.2, Design, the Normal Procedures Flightdeck Checklist was designed to be quickly and easily accomplished in a logical time sequence during the flight. Checklist groupings were selected so the items were consistent with established flow patterns and could be quickly accomplished.

[85] Source: USAirways A319/320/321 TM, Section 5.1.4 Multipurpose Control and Display Unit (MCDU).
[86] Source: USAirways A319/320/321 PH, Section 2. 3 Normal Procedures Flightdeck Checklist.

Checklists were the means for ensuring critical items were accomplished. If an item could affect flight safety in a direct way, it was considered for inclusion in the checklist.

Normal checklists were "Do-Verify". Flow patterns and procedures triggered by operation events were used to complete all required normal actions prior to checklist usage.

Read and Do checklists (i.e., Safety & Power On and Securing) were directly referred to when accomplishing and contained all items necessary to accomplish the specific task for which they are designed.

15.1.2 Checklist Content

According to the USAirways A319/320/321 PH, Section 2.3.3, Content, the Normal Procedures Flightdeck Checklist was a comprehensive checklist made up of the following individual flight phase checklists:

—*Safety & Power On*
—*Before Start*
—*Taxi*
—*After Takeoff*
—*Descent - Approach*
—*Landing*
—*Shutdown*
—*Secure*

The USAirways A319/320/321 PH, Section 2.3.3 Content, stated:

> *These checklists contained only those procedural steps which, if omitted, had a direct and adverse impact on normal operations.*

According to the USAirways A319/320/321 PH, Section 2.3.4 Challenge and Response Concept, USAirways' checklists incorporated the challenge and response concept, and stated the following:

> *Challenger.*
> *The person who reads the checklist and verbally issues the CHALLENGE.*
>
> *Responder.*
> *The person who verbally issues the RESPONSE.*
>
> *Two Basic Principles.*
> *1. The challenger calls aloud (except for those checklists which are accomplished silently) all CHALLENGES and ensures the associated RESPONSES are correct.*
> *2. The responder visually verifies each specific switch position or action matches the correct checklist RESPONSE.*

15.2 Flightdeck Preparation Flow

According to the USAirways A319/320/321 PH Section 2a.6.1 General, pilots were required to conduct a Flightdeck Preparation Flow to ensure all systems and equipment were operating properly.[87] This flow was accomplished on the first flight of the day, after a crew change, prior to flights farther than 162 NM from the nearest shoreline, after maintenance had been performed in the flightdeck, or when the flightdeck had been left unattended and not in view of a pilot crewmember.

According to interviews with the accident crew, the FO initialized the FMS on the accident flight when the crew arrived at the airplane as part of the Flightdeck Preparation Flow.[88] As previously mentioned, the captain was the PF for the accident flight and the FO was the PM. According to the USAirways A319/320/321 PH, Section 2b.1 Prior to Departure, normally, the PF completed the FMS initialization, though the PM could complete the FMS initialization when operationally expedient.

Pilots had the option to manually enter a flight plan into the FMS or allow the data to "uplink" the flight plan into the FMS. According to the USAirways A319/320/321 PH, Section 2b.1 Prior to Departure, page 2b-2, a flight plan uplinked to the FMS would automatically insert the following items into the FMS:

- *Flight plan minus any departure or arrival procedure (SID or STAR)*
- *Flight number*
- *Wind and temperature information for climb, cruise, and descent (automatically inserted)*
- *Performance information (cruise altitude, weights, etc.)*

Entering the flight plan into the FMS (either manually or via uplink) did not enter the planned departure runway or departure procedure, and the pilot was required to manually enter the planned departure runway after the flight plan had been entered. The process for entering the planned departure runway into the FMS was described in the USAirways A319/320/321 PH, Section 2b.1.6 FMS/FMS Initialization, and included the following step:

5. F-PLN A page...Complete

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[87] According to the USAirways A319/320/321 PH, Section 2.2.1 General/Flows stated: "Flows are established to configure aircraft systems and/or accomplish required tasks in an organized manner without reference to a checklist. These tasks may be accomplished as appropriate and time permits up to the start of each flow. Once all flow triggers are met, complete the entire flow in order to ensure previously accomplished tasks have been completed. For example, if the FMS loading was previously accomplished, do not re-accomplish loading during the flow, just ensure its completion. If a flow involves both pilots (e.g., Flightdeck Preparation Flow, Before Start Flow, etc.), both must accomplish the flow before starting the next flow. For example, the captain or first officer will both accomplish their Flightdeck Preparation Flows before either of them start their Before Start Flows. When accomplishing flows, pilots are expected to complete all items in order from memory. Applicable checklists (except Safety & Power On and Securing) are initiated after the flow is completed."

[88] For additional information, see Attachment 7 – A320 Standard Operating Procedures.

Check, modify, or insert (as applicable) the F-PLN in the following order, according to the data given by ATIS or ATC:

- *Lateral revision at departure airport (1L). Select DEPARTURE (1L). Select RWY, then SID, then TRANS using scroll keys.*

Throughout the FMS initialization, the crew was required to check and correct uplinked data or enter data as required without uplink.[89] After initialization of the FMS and entry of the ATC clearance, the crew was required to conduct a route verification.

15.2.1 ATC Route Clearance Verification[90]

For all flights, once the FMS flight plan was loaded and the ATC departure clearance was received, the pilot who entered/uplinked the FMS route must coordinate with the other pilot to perform an ATC Route Clearance Verification.[91] The pilot who entered/uplinked the route (normally, the PF) ensured the routing (to include altitudes and speeds) was correct by referring to the ATC departure clearance, flight release, and charted departure procedure (as applicable), while the other pilot (normally, the PM) read aloud the route from the MCDU FLT PLAN page.

If the FMS routing was previously verified against the flight release (i.e., accomplished when loading the FMS route on applicable international flights using the "Master" Flight Release), then all that remained was for the pilots to ensure the ATC departure clearance matched the FMS routing.

According to interviews with the accident crew, the route verification was completed for the accident flight; however neither pilot noticed that the wrong runway had been entered into the FMS.[92]

The USAirways A319/320/321 PH, Section 2b.1.6 FMS/ATC Route Clearance Verification, stated the following:

> *This procedure ensures the ATC route clearance is the same as the route loaded into the FMS.*[93]

Further, the USAirways A319/320/321 PH stated that conducting a route verification "lessens the risk of seeing what is expected versus what is *actually* displayed."[94]

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[89] Source: USAirways A319/320/321 PH, Section 2b.1.6 FMS, page 2b-4.

[90] Source: USAirways A319/320/321 PH, Section 2b.1.6 FMS.

[91] According to the USAirways FOM, paragraph 2.2.8 Requesting ATC Clearance, for all flights both pilots must review the ATC clearance for revised segments.

[92] The ATC route clearance verification did not specifically include verifying the departure runway.

[93] According to the Managing Director of Fleet Technical Operations at USAirways, the route verification was included procedurally on the Airbus fleet several years ago after USAirways data indicated that on international operations they would rarely see navigational errors attributed to preflight procedures, and the airline took that as the model. There was a higher level of awareness of the importance in international operations, and the airline mirrored those procedures for all airplanes, including the A320 fleet. See Attachment 1 – Interview Summaries.

[94] Source: USAirways A319/320/321 PH, Section 2b.1.6 FMS/ATC Route Clearance Verification.

On March 26, 2014, the Operations Group conducted simulator testing in an A320 simulator at the USAirways training facility in Charlotte, NC.[95] Investigators entered 27R at PHL into the flight plan to document the visual cues available to the pilots during the route verification.[96] Upon entry of 27R into the flight plan, the MCDU flight plan page showed 27R at the 1L (first left) position (see Photo 2).

Photo 2: MCDU with PHL runway 27R (indicated) inserted in the flight plan page.[97]

In addition, runway 27R was visible on the ND (see photo 3).

[95] See Attachment 12 – CLT Simulator Test.

[96] A review of the FMS database (USA3140301_1), dated 06 March 2014 to 02 April 2014, showed that both PHL 27L and 27R runways were available in the FMS software.

[97] Photo taken by the NTSB Operations Group Chairman on March 26, 2014 at the USAirways CLT Training Facility. See Attachment 12 – CLT Simulator Test.

Photo 3: A320 ND Display with runway 27R (indicated) in flight plan indicated.[98]

15.3 Before Start Checklist Flow

According to the USAirways A319/320/321 PH, Section 2b.2 Before Start Flow, approximately 15 minutes prior to departure and after the ATC Route Clearance Verification was completed, the pilots were required to conduct a Before Start flow to prepare the airplane for engine start.[99] Included in the flow (for the pilot who would be PF) was a departure briefing.

The departure briefing was to include a review of the expected taxi route and departure, with emphasis on anticipated track and altitude restrictions. The USAirways A319/320/321 PH, Section 2b.5.2 Departure Briefing, stated that the briefing was to include the following items:

> *Brief the following items (use FMS and electronic displays when applicable):*
>
> *—ATC Clearance*
> *—Planned taxi route/hot spots/runways crossings*
>
> *• Note •*
> *Actual taxi route may be different.*
>
> *—Takeoff performance*
> *—SID or IFR Departure*
> *—Initial*
> *•heading*
> *•altitude*

[98] Photo taken by the NTSB Operations Group Chairman on March 26, 2014 at the USAirways CLT Training Facility. See Attachment 12 – CLT Simulator Test.
[99] For additional information, see Attachment 7 – A320 Standard Operating Procedures.

•fix or route segment

15.3.1 Departure Briefing

Departure Briefing

(Use FMS and electronic displays when applicable and ensure ATC route clearance verification accomplished)

— ATC clearance

— Planned taxi route/hot spots/runway crossings

Note: Actual taxi route may be different

— Takeoff performance

— SID or IFR departure

— Initial

- heading
- altitude
- fix or route segment

— Any applicable special considerations such as

- MEL item(s)
- unique airport advisory page(s) briefing items
- unique noise abatement procedures
- unique engine failure during takeoff procedures
- significant terrain/obstacles in terminal area relative to departure routing
- significant weather conditions

— Any other known risks and intentions

Figure 12: USAirways A320 Departure Briefing. [100]

15.3.2 Before Start Checklist[101]

The Before Start Checklist was found in the USAirways A319/320/321 PH, Section 2.4 Normal Procedures Checklist.[102] According to USAirways A319/320/321 Standard Operating Procedures (SOPs), following the departure briefing and after receipt of the fuel slip, the Captain would call for the "Before Start" Checklist, which included the following:

Departure Briefing. . . . .[C] . . . . .Reviewed[103]

---

[100] Source: USAirways A319/320/321 PH, Section 2.4 Normal Procedures Checklist.
[101] Source: USAirways A319/320/321 PH, Section 2.4 Normal Procedures Checklist.
[102] The A319/320/321 Normal Checklists were located on a card in the A320 cockpit for crew reference.
[103] Source: USAirways A319/320/321 PH 2b.9 Before Start Checklist. The [C] in the checklist indicated a response by the captain.

Before Start

RCDR GND CTL	[C]	ON
FDML	[C]	On Board
FUEL QTY	Verify	___Req, ___OB
Oxygen	Verify	Checked
Cabin SIGNS	[C]	ON
ECAM	[C]	Checked
PARK BRK	[C]	ON, Checked
MCDU	[C]	Set
Altimeters	Verify	__.__
Departure Briefing	[C]	Reviewed
Before Start Checklist	[FO]	Complete

Figure 13: USAirways A320 Before Start Checklist.[104]

15.4 Single Engine Taxi

According to interviews, the accident crew elected to begin their taxi to the departure runway on a single engine. According the USAirways A319/320/321 PH, Section 2c.3.9 Single Engine Taxi, single engine taxi was the normal operating procedure and normally accomplished with the #1 engine running. This allowed pressurization of the green hydraulic system for nose wheel steering (for most aircraft) and normal brakes. When taxiing with an engine shutdown, the crew must be aware of system requirements (i.e., hydraulics, brakes, electrical, and pneumatics), and directed to use the following general guidelines:

> *1. Consider crew experience, workload requirements, and passenger comfort.*
> *2. Consider single engine taxi if anticipated delay time will exceed five (5) minutes.*
> *3. Consider gross weight, temperature, visibility, ramp congestion and taxiway surface conditions before deciding to single engine taxi away from the gate.*[105]

15.5 Takeoff Data Entry

The USAirways A319/320/321 PH, Section 2c.3.10 Takeoff Data Entry, provided steps for entering the takeoff data into the FMS (via uplink or manually), and stated the following:

> *When the FINAL W&B is available, uplink (if available) or manually enter performance data as soon as workload permits. To ensure both pilots are aware of takeoff performance issues and to add a second level of redundancy, the Final W&B should be discussed. This may include the RAMP weight, MTOW for the planned runway/flap combination, thrust setting or other items deemed necessary by the flight crew.*

The USAirways A319/320/321 PH, Section 5.8.1 Automated System, stated in part:

[104] Source: USAirways A319/320/321 PH, Section 2.4 Normal Procedures Checklist.
[105] Source: USAirways A319/320/321 PH, Section 2c.3.9 Single Engine Taxi, page 2c-13.

ACARS TOW and W&B information is printed out automatically through the uplink system using the flightdeck printer. Each printout has a Header and TOW Section, A Final Weight and Balance Section, an Adjusted V-Speeds Section, and a Ground Security Incident (GSI), Live Animal (L/A), and Restricted Articles (R/A) Notification Section.[106]

The takeoff data required to be entered into the MCDU included $V_1/V_R/V_2$ (157/159/159 for the accident flight) and the FLEX temperature (53°C for the accident flight), per the final weight and balance sent to the airplane.[107]

There were two methods of entering the takeoff data; automatically via uplink, or manually by inserting the V-speeds and FLEX temperature values directly into the MCDU.

The automatic method (uplink) was available when the TAKEOFF DATA UPLINK message was displayed in the MCDU scratchpad.[108] The USAirways A319/320/321 PH, Section 2c.3.10 Takeoff Data Entry, stated:

Automatic Uplink.
When the TAKEOFF DATA UPLINK message is displayed on the MCDU scratchpad:
1.Enter weight information
If before engine start:
On INIT B page ensure the ZFW and ZFWCG fields match the final weight and balance values. If the uplinked values are different, manually enter the correct values.
Enter FOB from the final weight and balance into BLOCK. In order for the performance to uplink correctly, the BLOCK fuel must match the fuel on the final weight and balance. The value will automatically be corrected to actual fuel on board after engine start.

If after engine start:
On FUEL PRED page confirm or enter zero fuel weight and zero fuel weight CG. Ensure the ZFW and ZFWCG fields match the final weight and balance values. If the uplinked values are different, manually enter the correct values.
2.Press PERF key
3.Press UPLINK TO DATA (6L) on PERF TAKEOFF page
4.Press RECEIVED TO DATA (6L) on the UPLINK DATA REQ page
5.If MAX TO data will be used, scroll to the data corresponding to the planned runway using the NEXT PAGE key. Otherwise, if FLEX TO data will be used , select FLEX TO (4R) and scroll to the planned runway.
6.Select INSERT UPLINK (6R)*
This prompt is only available after the first engine start. Selected runway must match the flight plan runway.
Uplinked Data...Verify

[106] For a copy of the accident flight's ACARS TOW and Final Weight and Balance printout, see Attachment 4 – AWE1702 Paperwork.
[107] See Attachment 4 – AWE1702 Paperwork.
[108] When the TAKEOFF DATA UPLINK message was displayed in the MCDU scratchpad, a paper version of the final weight and balance would be automatically printed on the cockpit printer. See Attachment 4 – AWE1702 Paperwork.

For step 6 above, an asterisk would be next to the runway originally entered into the flight plan, allowing the pilot to uplink the takeoff data. If the planned runway for departure was different than the runway that had an asterisk next to it (i.e. the runway entered into the flight plan was not the planned runway for departure), the pilot would have to reenter the planned runway for departure into the flight plan (via lateral revision) and manually insert the new takeoff data.

The manual method of entering the takeoff data was covered in the same section of the USAirways A320, and stated:

Manual Entry.
If uplink is not available, and the Final W&B has been received, the takeoff data may be entered before engine start.
1. Enter Weight information
If entry is made before engine start:
Enter ZFW, ZFWCG, and FOB (BLOCK) on INIT B page.
If entry is made after engine start:
Enter ZFW and ZFWCG on the FUEL PRED page.
2. PERF TAKEOFF page..Complete
a. V1, VR, V2 ....Enter
b. FLX TO TEMP (if using FLX thrust)...Enter
c. THR RED/ACC Altitude..Set or check
•Distant: Field elevation plus 1,000 feet/Field elevation plus 1,000 feet
•Close-in: Field elevation plus 1,500 feet/Field elevation plus 3,000 feet
•See Airport Advisory Page for airport specific altitudes.
d.ENG OUT ACC Altitude..Set or check
Confirm ENG OUT ACC altitude matches Jeppesen -7 (e.g., 10-7)flap retraction altitude, if applicable, otherwise 1000 ft AFE.
e.FLAPS/THS...Enter
.TO SHIFT (if required)...Enter
If takeoff is to be from an intersection, enter takeoff SHIFT distance.

• Note •
Refer to the TPS or request from ATC the runway remaining distance from the intersection.

3. PERF Climb, Cruise, Descent, Speed Preselection............As required
a. Enter green dot speed on the PERF CLB page (4L). Once the CLB phase is active, the preselected speed will be displayed in the FCU speed window and on the PFD (blue symbol). When appropriate, climbing through 3,000 feet AFE, the pilot will resume the managed speed profile by pressing the SPD selector on the FCU.

b. SPD LIM defaults to 250 knots below 10,000 feet in the managed speed profile. This may be either cleared or modified on the VERT REV page at the origin (or a climb waypoint).

According to the FO's interview, she received the takeoff data via ACARS after pushback from the gate, entered the weight and balance via uplink, and also entered the takeoff data for a FLEX takeoff, but could not remember if she entered the takeoff speeds via uplink or manually.[109]

Both pilots indicated that they planned to conduct a reduced power FLEX takeoff. The USAirways A319/320/321 PH, Section 2c.3.10 "FLEX Takeoff" stated the following:

The FLEX thrust takeoff procedure significantly increases engine reliability and efficiency while reducing fuel consumption, engine wear, and operating costs. The FLEX thrust method uses a thrust setting appropriate to aircraft weight and runway requirements. Whenever operationally feasible, the use of FLEX thrust for takeoff is strongly recommended.

- *FLEX thrust is permitted on wet runways because accelerate/stop distance is adjusted for the wet condition*
- *Takeoff at FLEX thrust is not allowed on contaminated runways (i.e., ice or greater than 1/8 inch of snow, slush, or standing water)*

Further, the same section of the USAirways A319/320/321 PH stated the following for takeoff data inserted into the FMS via uplink:

Selected runway must match the flight plan runway.[110]

During the March 26, 2014 simulator testing in an A320 simulator at the USAirways training facility in Charlotte, North Carolina, NTSB staff entered the takeoff data and FLEX temperature (53°C) into the FMS with runway 27R inserted in the flight plan, as indicated from crew interviews, and the speeds and FLEX temperature were visible on the MCDU Takeoff page (see Photo 4).

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[109] When the TAKEOFF DATA UPLINK message was displayed on the MCDU scratchpad, weight and balance and takeoff data could be directly inserted into the proper fields in the MCDU without having to manually type the numbers to be inserted. Source: USAirways A319/320/321 PH, Section 2c.3.10 Takeoff Data Entry.

[110] Source: USAirways A319/320/321 PH, Section 2c.3.10 FLEX Takeoff. According to the FAA Pilot's Handbook on Aeronautical Knowledge (FAA-H-8083-25A), Chapter 10, page 10-27): "V1—critical engine failure speed or decision speed. Engine failure below this speed shall result in an aborted takeoff; above this speed the takeoff run should be continued. VR—speed at which the rotation of the aircraft is initiated to takeoff attitude. The speed cannot be less than V1 or less than 1.05 times VMC. With an engine failure, it must also allow for the acceleration to V2 at the 35-foot height at the end of the runway. V2—the takeoff safety speed which must be attained at the 35-foot height at the end of the required runway distance. This is essentially the best one-engine operative angle of climb speed for the aircraft and should be held until clearing obstacles after takeoff, or until at least 400 feet above the ground."

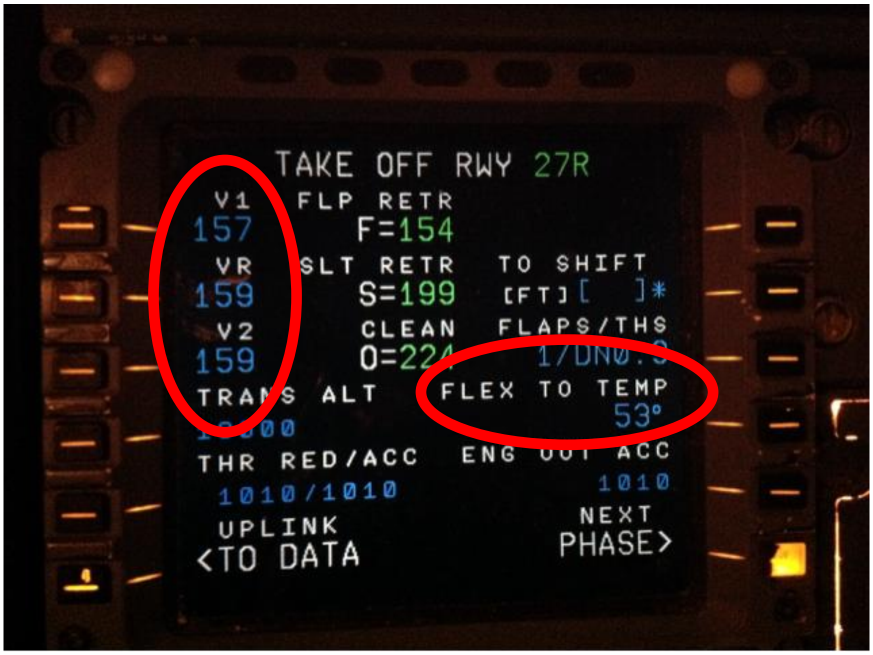

Photo 4: MCDU Takeoff page with V-speeds (indicated) and FLEX temperature (indicated) inserted for PHL runway 27R.[111]

15.6 Taxi Flow

According to the USAirways A319/320/321 PH, Section 2c.7 Taxi Flow, after departing the gate with the final weight and balance received and both engines running, the pilots were required to conduct a Taxi Flow. This flow was used to ensure the aircraft was ready for takeoff. Required tasks could be accomplished as time permitted up to and including the start of the flow.

The USAirways A319/320/321 PH Section 2c.8.3 Captain's Taxi Flow/Expanded Flow, included the following step:

Takeoff Data/Flex. . . . . Checked
Ensure the PERF TO page is completed.

The USAirways A320 PH Section 2c.9.3 First Officer's Taxi Flow/Expanded Flow, included the following step:

Takeoff Data/Flex. . . . . Checked
Ensure correct data is entered on the FUEL PRED page and the PERF TO page.

15.6.1 Taxi Checklist[112]

The Taxi Checklist was found in the USAirways A319/320/321 PH, Section 2.4 Normal Procedures Checklist. According to USAirways A319/320/321 SOPs, after both engines were

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[111] Photo taken by Operations Group Chairman March 26, 2014 during simulator testing in an A320 simulator at the USAirways training facility in Charlotte, NC.
[112] Source: USAirways A319/320/321 PH, Section 2.4 Normal Procedures Checklist.

started and the Taxi flows were completed, the captain would call for and the FO would read the first portion of the Taxi Checklist "to the line."[113] This was a "Do-Verify" checklist.

According to the USAirways A319/320/321 PH, Section 2c.13.1 Taxi Checklist/General, the second step of the Taxi Checklist included the following:

> *Takeoff Data. . . . . .Verify . . . . .___, ___, ___, FLEX ___ / TOGA*
>
> *The first officer will read directly from the paper Final Weight and Balance (and TPS or Performance Chapter of the Pilot Handbook, if applicable) the values for V1, VR, V2, and the flex temperature or state "TOGA", as applicable. The captain will confirm the correct values are displayed: V1 (PFD), VR (PERF page), V2 (PFD), Flex temperature or TOGA (Upper ECAM).*

This procedure was revised and included in the USAirways A319/320/321 PH in 2008, and was also covered in a May 2008 "Recent Developments" article sent to Airbus pilots by the Fleet Captain, which stated, in part:

> *This verification requiring both pilots to review the aircraft weight in this manner provides a proactive safety net that should ensure accurate entries have been made so weight/speed computations can be relied on throughout the flight.*
>
> *Your revision highlights note: The First Officer will read the takeoff data directly from the paper final weight and balance (and TPS or performance chapter of the PH, if applicable). The Captain will confirm the correct values are displayed: V1 (PFD), VR (PERF page), V2 (PFD), flex temperature or TOGA (Upper ECAM), Weight (lower ECAM).*

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[113] The ➤ symbol in the checklist indicated "the line" and was placed in the checklist to indicate a break in the sequence. Normally, some action (i.e., pushback, selecting final landing flaps, etc.) must occur before the checklist could proceed. When reading the checklist and the next item was in the line, the challenger would state "Down to the Line". Source: USAirways A319/320/321 PH, Section 2.3.5 Checklist Format.

Taxi

Flaps	Verify	___Planned, ___Indicated
Takeoff Data	Verify	___, ___, ___, FLEX___/TOGA
Weight	Verify	____
STAB & TRIM	Verify	___%, Zero
Flight Controls	Verify	Checked
ENG ANTI ICE	*[C]*	ON or Off
ECAM	Verify	T.O., No Blue, STS Chkd
➤		
Runway & FMS	Verify	Rwy ___, Checked
T.O. Min Fuel	Verify	___Req, ___OB
Flight Attendants	*[FO]*	Notified
ENG MODE	*[FO]*	NORM or IGN
TCAS	*[FO}*	TA/RA
Taxi Checklist	*[FO]*	Complete

Figure 14: USAirways A320 Taxi Checklist.[114]

15.7 Before Taking the Runway Flow

According to USAirways A319/320/321 SOPs, the Before Taking the Runway Flow was used to ensure the flight attendants were seated and the aircraft was ready for imminent takeoff, and to occur approximately 1-3 minutes prior to taking the runway.[115] The Taxi Checklist below the line items were then to be accomplished prior to taking the runway. According to the accident crew interviews, the below the line items were accomplished after ATC had given the crew a clearance to "line up and wait" at 1822:35.[116]

The USAirways A319/320/321 PH, Section 2.9.78 Dealing with ATC Clearance Changes, page 2-20, stated the following:

> *Proper use of automation will reduce your workload, freeing you to complete other tasks. Whenever possible, avoid FMS programming during critical phases of flight. Complete as much programming as possible during low workload phases.*

The first step of the Taxi Checklist (below the line), responded to by both pilots, included the following:

> *Runway & FMS. . . . . Verify . . . . . . Rwy ___, Checked*

[114] Source: USAirways A319/320/321 PH, Section 2.4 Normal Procedures Checklist.
[115] Source: USAirways A319/320/321 PH, Section 2c.10 Before Taking the Runway Flow.
[116] According to the USAirways A319/320/321 PH, Section 2.9.10 MCDU Screen Management, for takeoff the PF should display the F-PLN (Flight Plan) page, and the PM should display the PERF - TAKE OFF (Performance – Take off) page on their respective MCDU screens.

Both crewmembers must ensure the aircraft is approaching the assigned departure runway. Ensure any takeoff runway and/or departure clearance changes are programmed into the FMS and briefed.[117]

According to the USAirways A319/320/321 PH, Section 2c.10 Before Taking the Runway Flow, both pilots were required to ensure any takeoff runway and/or departure clearance changes were programmed into the FMS, and to verify the runway using runway displayed on ND, heading indicator, signage and any additional means available.

According to interviews with the accident crew, ATC cleared the flight to line up and wait on runway 27L, and as they ran the below the line checklist items while taxiing into position on the runway, the captain noticed that the FMS had runway 27R inserted instead of 27L. He then requested the FO to change the runway in the FMS.[118]

15.8 Change of Departure Runway

According to accident crew interviews, as the airplane was taxiing onto runway 27L, the FO changed the runway in the FMS from 27R to 27L on the flight plan page of the MCDU. The process to change runways in the FMS was detailed in the USAirways A319/320/321 TM, Section 5a.4.2 Start and Before Takeoff, page 5a-102.[119] The procedure called for the pilot to change the departure runway on the flight plan page of the MCDU (lateral revision) and reinsert the new runway into the flight plan. After changing the runway in the flight plan page, prompts to reinsert the takeoff performance data (V-speeds and FLEX temperature) were displayed on the TAKEOFF PERF page for the newly selected runway (See Figure 16 below) and a scratchpad message appeared in the MCDU scratchpad field that said “CHECK TAKE OFF DATA” (See Photo 5).

The USAirways A319/320/321 TM, Section 5a.4.2 Start and Before Takeoff, page 5a-103, stated:

An amber “CHECK TAKEOFF DATA” scratchpad message is triggered after the new RWY is inserted.

and:

The previous takeoff data (V1, VR, V2, FLX TO values) appear in small blue font beside the corresponding fields. The PFD takeoff speeds are removed from the PFD speed scale. The FLAPS/THS, THR RED/ACC and ENG OUT ACC data, if entered, will remain.

[117] Source: USAirways A319/320/321 PH, Section 2.4 Normal Procedures Checklist.
[118] See Attachment 1 – Interview Summaries.
[119] See Attachment 8 – Change of Departure Runway.

Figure 15: Sample MCDU Takeoff page.[120]

According to the USAirways A319/320/321 TM, Section 5a.4.2 Start and Before Takeoff, if the previous V-speeds and FLEX temperature displayed in blue fonts (see Figure 16) were the same as the new V-speeds and FLEX temperature for the runway selected, the pilot could confirm those speeds in the MCDU (through the 6R button) and the speeds would populate the V-speed and FLEX temperature field, and then display the speeds on the PFD speed scale and the FLEX temperature on the upper ECAM. Otherwise, the pilot could manually enter the V-speeds and FLEX temperature on the Take Off page of the MCDU which would also populate the V-speeds on the PFD speed scale.[121]

The FO told NTSB staff she could not remember if they received the "CHECK TAKE OFF DATA" message, and said "we should have gotten one" since the takeoff numbers were not entered in the FMS. There was no aural alert when the "CHECK TAKE OFF DATA" message

[120] Source: USAirways.

[121] According to the USAirways A320 Check Airman and the Chairman of the A320 Standards Committee, this feature was part of an upgrade from version FMS1 to FMS2. With FMS2, all the previous V-speeds migrated to the right of the entry box after a runway change in the MCDU, which only required the pilot to confirm them or manually enter them if required. The pilots would then check the speeds against the weight and balance or takeoff performance system (TPS). Pilots received a bulletin about the changes from FMS1 to FMS2 and were trained on the differences in subsequent CQT following the upgrade. See Attachment 1 – Interview Summaries.

came up. She further said if she had realized that at that point they had that message, she would have told the captain they needed a few minutes. [122]

The USAirways A319/320/321 PH, Section 2.9.10 MCDU Screen Management, page 2-21 stated:

> *The scratchpad of the MCDU must be kept "clear." If a scratchpad message appears - interpret and act on the message if required, then clear the scratchpad. See Controls & Indicators 7d.1.4.*

During the March 26, 2014 simulator testing in an A320 simulator at the USAirways training facility in Charlotte, North Carolina, NTSB staff conducted a runway change in the MCDU from runway 27R to 27L without entering the new takeoff V-speeds or a FLEX temperature, and documented the MCDU screen, the PFD and the ECAM. Following the runway change in the MCDU, the "CHECK TAKE OFF DATA" message was visible in the MCDU scratchpad and the upper ECAM indicated a TOGA target power setting since no FLEX temperature was entered (see Photos 5 and 6).

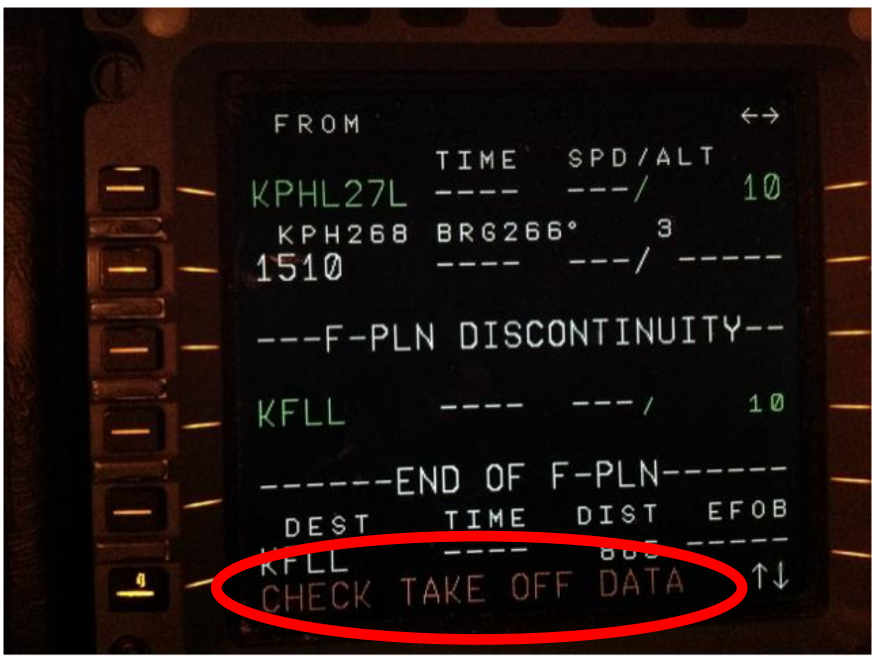

Photo 5: MCDU flight plan page after runway change (27R to 27L), with MCDU message (indicated).[123]

[122] See Attachment 1 – Interview Summaries.
[123] Photo taken by Operations Group Chairman March 26, 2014 during simulator testing in an A320 simulator at the USAirways training facility in Charlotte, NC.

Photo 6: Upper ECAM without FLEX temperature inserted in MCDU (TOGA indicated).[124]

There were no V-speeds indicated on the PFD speed tape, and a red "SPD SEL" was visible at the top of the speed tape (see Photo 7). The USAirways A319/320/321 TM, Section 10.2.5 Indications on PFD, stated:

> *Takeoff Speeds*
> *If the V speeds are not entered in the MCDU, a red "SPD SEL" message will appear on the top of the speed scale.*

[124] Photo taken by Operations Group Chairman March 26, 2014 during simulator testing in an A320 simulator at the USAirways training facility in Charlotte, NC.

Photo 7: PFD after runway change with no V-speeds inserted in MCDU and SPD SEL on speed tape (indicated).[125]

Further, column 1 of the FMA did not display any indication of autothrust operation (see Photo 8).

Photo 8: Autothrust column of the FMA (red circle).[126]

[125] Photo taken by Operations Group Chairman March 26, 2014 during simulator testing in an A320 simulator at the USAirways training facility in Charlotte, NC.
[126] Photo taken by Operations Group Chairman March 26, 2014 during simulator testing in an A320 simulator at the USAirways training facility in Charlotte, NC.

The USAirways A319/320/321 TM, Section 5a.4.3 Takeoff and Transition to Climb, stated:

> *FMGS Phase change – Preflight to Takeoff. The FMGS transitions automatically from the preflight phase to the takeoff phase when the following conditions are met:*
> *— Thrust levers are set to the FLEX or TOGA detent, and*
> *— Left or right EPR is above a defined value, or*
> *— Ground speed is above 90 knots*
>
> *Pilot Indications. When the FMGS switches from the PREFLIGHT phase to TAKEOFF phase:*
> *— Flight Mode Annunciator (FMA) displays MAN TOGA or MAN FLEX XX*

Both accident pilots indicated in their NTSB post-accident interviews that runway changes were not unusual, though both said they usually occurred earlier in the taxi. Both pilots also indicated that they had been trained on how to conduct a runway change in the MCDU, and the captain further stated that he had been shown in the simulator what the displays looked like when there were no speeds entered, and it was uncommon to have the wrong runway loaded in the FMS.[127]

The USAirways A320 Fleet Captain and several USAirways check airmen told NTSB staff that A320 pilots at USAirways were regularly trained on runway changes. A review of USAirways A320 training indicated that pilots were taught MCDU runway changes in initial (Qualification) training. Pilots were also taught runway changes in recurrent training (Continuing Qualification) during the 2009/2010 training cycle (Event Set 2) and the 2013/2014 training cycle (Event Set 2).[128]

15.9 Takeoff

At 1821:23, the PHL Tower advised AWE1702 they would be next for departure. AWE1702 acknowledged their sequence four seconds later, and according to the FO, the crew then started the second engine. At 1822:35 AWE1702 was cleared to line up and wait on runway 27L, and at 1823:26 AWE1702 was cleared for takeoff.[129]

The USAirways A319/320/321 PH, Section 2b.11.5 Engine Warm-Up, stated:

> *Operate engines for at least 5 minutes prior to applying takeoff thrust to allow engine temperature to stabilize. Exception: If an engine has been shut down for 1 and 1/2 hours or less, then the 5 minute warm-up can be reduced to a minimum of 3 minutes (workload permitting).*

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[127] See Attachment 1 – Interview Summaries. Further, a review of the USAirways A320 training curriculum showed that during the A320 qualification course (IPT Session 7 and SPOT training Session 1), the instructor was guided to demonstrate the indications associated with setting FLEX thrust when TOGA was required.

[128] The Captain's most recent proficiency training occurred on December 19, 2013, and the FO's most recent CQ occurred on May 15, 2013.

[129] FDR data indicated that the airplane had a ground speed of zero (0) knots for about 11 seconds prior to accelerating for takeoff.

The USAirways A319/320/321 PH, Section 2.3.6 Procedures, stated in part:

> *Even though the following guidance clearly delineates crewmember responsibilities, it does not alleviate the first officer from bringing to the captain's attention a checklist or checklist item he feels has been overlooked, improperly accomplished, or delayed too long.*

and:

> *Standard Operating Procedures indicate when to call for the appropriate checklist.*
>
> > *—Flow items should be accomplished before calling for the pertinent checklist. The crew should accomplish their specific functions and duties by following established flow patterns.*
> > *—Checklist should not be initiated until sufficient time and attention can be devoted to its expeditious completion.*

The USAirways FOM, Section 2.3.3 Ready for Takeoff, stated:

> *ATC assumes turbine-powered aircraft are ready for departure upon reaching the end of the runway. Therefore, ATC should be advised of any known delays.*

The captain told NTSB staff that once cleared for takeoff on runway 27L, he set FLEX thrust with the thrust levers, and the performance and acceleration of the airplane on the takeoff roll "was spot on."[130]

The USAirways A319/320/321 PH, Section 2d.1.2 Setting Takeoff Thrust, stated the following:

> *The PF will advance the thrust levers to 50% N1 (CFM), 1.05 EPR (IAE) allow the engines to stabilize momentarily at that thrust and cross-check engine instruments. Then, the thrust levers are positioned in the FLEX or TOGA detent. Takeoff thrust should be set by 40 knots.*

The FLEX thrust method used a thrust setting appropriate to aircraft weight and runway requirements. USAirways "strongly recommended" pilots use FLEX thrust for takeoff whenever operationally feasible to increase engine reliability and efficiency while reducing fuel consumption, engine wear, and operating costs.[131] FLEX thrust required that a FLEX temperature was entered in the MCDU.

After setting FLEX thrust, USAirways A319/320/321 SOPs called for the PF to announce "FLEX", and the PM would verify takeoff thrust on the E/WD and call "FLEX Set". The captain would then maintain control of the thrust levers, and the PM would verify FLEX thrust

[130] See Attachment 1 – Interview Summaries.
[131] Source: USAirways A319/320/321 PH, Section 2c.3.10 Takeoff Data Entry – FLEX Takeoff.

was set by verifying the FMA indications on top of the PFD stated “MAN FLX” with the FLEX temperature indicated (See Photo 8).[132]

Photo 8: Sample FMA indications as FLEX thrust was set with FLEX temperature (55°) entered into the MCDU.[133]

Photo 9: A320 Upper ECAM with FLEX temperature (53°) set (indicated).[134]

At 80 knots, the PM should call “80” and PF should respond with “checked.”. At V_1 minus 5 knots, the captain would remove his hand from the thrust levers, and at V_R, the PF would initiate a 3 degree/second rotation up to 15 degrees. After liftoff, the PM would verify a positive rate on the vertical speed indicator (VSI), and call “positive rate”, and the PF would verify the positive rate of climb and call “gear up.”[135]

[132] For additional information, see Attachment 7 – A320 Standard Operating Procedures.
[133] Source: USAirways A319/320/321 TM, Section 5.4.3 Takeoff and Transition to Climb.
[134] Photo taken by Operations Group Chairman March 26, 2014 during simulator testing in an A320 simulator at the USAirways training facility in Charlotte, NC.
[135] For additional information, see Attachment 7 – A320 Standard Operating Procedures.

According to interviews, the FO could not remember if she saw a FLEX temperature on the FMA, and the captain stated he did not look to see if there was a FLEX temperature on the FMA since "they had just reviewed that."[136]

The USAirways A319/320/321 PH, Section 2d.1.2, Setting Takeoff Thrust stated, in part:

> *After the thrust levers are set, the PM should:*
>
> > • *compare LP rotor speed (N1) to N1 rating limit (CFM) or EPR indication to EPR rating limit(IAE) on ECAM E/WD.*
> >
> > • *Ensure correct FMA indications.*

15.9.1 Normal Takeoff Callouts

Normal takeoff callouts for the A320 were found in the USAirways A319/320/321 PH, Section 2d.4, page 2d-6.

[136] See Attachment 1 – Interview Summaries.

Takeoff to Flap Retraction		
Trigger	**PF**	**PM**
Commencing takeoff roll	• Advance thrust levers to approximately 50% N_1 (CFM) or 1.05 EPR (IAE) • Advance thrust levers to FLX or TOGA **"FLEX"** or **"TOGA"**	• Verify takeoff thrust on E/WD **"FLEX Set"** or **"TOGA Set"**
	•Capt assumes/maintains control of thrust levers	
80 kts	**"Checked"**	**"80"** • Check STBY airspeed
V_1 - 5 knots		**"V_1"**
	•Capt removes hand from thrust levers	
V_R	• Rotate at 3 degrees/sec to 15 degrees	**"Rotate"**
After liftoff	• Verify positive rate of climb **"Gear Up"** • Maintain F/D commanded attitude • Establish initial climb speed of not less than V_2+10 kts	• Verify positive rate of climb on VSI **"Positive Rate"** **"Gear Up"** • Position gear lever UP • Monitor speed and attitude
Above 100 ft. AFE	**"Autopilot 1"** or **"Autopilot 2,"** as appropriate	• Select autopilot on, if requested

Figure 16: Normal A320 Takeoff Callouts.[137]

15.9.2 "ENG THR LEVERS NOT SET" ECAM

According to preliminary FDR data and interviews with the accident crew, after application of takeoff thrust, the crew received an "ENG THR LEVERS NOT SET" ECAM message prior to 80 knots. The captain told NTSB staff that when they were cleared for takeoff he set the thrust to FLX and got a chime. He asked the FO what it was, and she said "thrust not set." He then told the FO "the thrust is set" and said he moved the levers slightly forward then back to the detent, to make sure they were in the detent. However, FDR data indicated that the thrust was initially set to the FLX detent, then reduced towards the CLB detent, then returned to the FLX detent.

The USAirways A319/320/321 PH, Section 2d.1.2 Setting Takeoff Thrust, stated the following:

[137] Source: USAirways A319/320/321 PH, Section 2d.4, page 2d-6. See also Attachment 7 – A320 Standard Operating Procedures.

If a FLEX temperature was not entered in the MCDU, and the thrust levers are positioned in the FLEX detent, a warning will be generated. In this case, move the thrust levers to TOGA detent and execute a max thrust takeoff. When the thrust levers are moved to the TOGA detent, the warning will be cancelled.

In addition, according to the USAirways A319/320/321 ECAM Supplemental Manual, page 506 "Non-Normals – Powerplant," an "ENG THR LEVERS NOT SET" ECAM message indicated that at least one FADEC engaged a takeoff thrust mode that was not in accordance with the position of the thrust levers. The takeoff thrust mode was engaged when the flight crew set the thrust levers above the CL (Climb) position.[138] The FLEX takeoff mode was armed only if the flight crew entered a FLEX TO TEMP on the MCDU that was above the outside air temperature (OAT). The USAirways A319/320321 ECAM Supplemental Manual, page 506, also stated the following:

If the flex mode is not armed, and the flight crew sets the thrust levers below or at the MCT/FLX position:
THR LEVERS . . . . MCT/FLX

During the March 26, 2014 simulator testing in an A320 simulator at the USAirways training facility in Charlotte, NC., NTSB Staff simulated a thrust set to FLX with no FLEX temperature entered in the FMS, and a MASTER CAUTION alert triggered (see Photo 10) and the "ENG THR LEVERS NOT SET" was seen on the ECAM. In addition, the ECAM showed a message directing the pilot to place the thrust levers to TOGA (see Photo 11).

Photo 10: Forward displays with master caution (indicated) when FLEX thrust set without a FLEX temperature.[139]

[138] According to Airbus, the "ENG THR LEVERS NOT SET" ECAM message and associated chime is triggered on the A320 3 seconds upon the thrust levers being placed above the CL (climb) detent.
[139] Photo taken by Operations Group Chairman March 26, 2014 during simulator testing in an A320 simulator at the

Photo 11: Upper ECAM when FLEX thrust set without a FLEX temperature, and ECAM message (indicated).[140]

According the FDR data and accident crew interviews, the thrust levers were never placed in the TOGA position on the accident flight.[141] When asked why he did not push the thrust to TOGA after he received "ENG THR LEVERS NOT SET" ECAM and chime, the captain told NTSB Staff it was "no harm" and left the thrust in FLX, and the reason he did not reject was because he had already briefed a FLEX takeoff and he did not know the speeds and assumed temperature had dropped out.

15.9.3 "Retard" Aural Alert on Takeoff

According to recorded data and interviews with the accident crew, on takeoff the crew received an aural "Retard" alert after setting FLEX thrust and at a speed of about 80 knots. The captain told NTSB staff he had never heard an aural "Retard" on takeoff, only knew of it on landing, and did not know what it was telling him.[142] He further said that at 80 knots when they received the aural "Retard" alert, he was not going to reject because procedurally they were at high speed, they had no red warning lights, and there was nothing to suggest a reject.

USAirways training facility in Charlotte, NC.

[140] Photo taken by Operations Group Chairman March 26, 2014 during simulator testing in an A320 simulator at the USAirways training facility in Charlotte, NC.

[141] According to the Airbus A319/320/321 FCOM, Abnormal and Emergency Procedures – Powerplant, page 251/256, when thrust levers are set to FLX without a FLEX temperature and the flight crew does not set the thrust levers to the TOGA position, the FADEC (Full Authority Digital Engine Control) will automatically select TOGA thrust after 8 seconds.

[142] See Attachment 1 – Interview Summaries.

The USAirways A319/320/321 TM, Section 5.1.9 AP/FD and A/THR Interaction, stated the following:

> *Retard Mode: commands A/THR to idle in the flare during AUTO LAND. IDLE is displayed on FMA column one and on the E/WD. RETARD callout is generated at 10' RA.*
>
> *• Note •*
> *Manual thrust reduction is required if A/THR disconnects in the flare. RETARD callout is generated at 20' RA.*

During the March 26, 2014 simulator testing in an A320 simulator at the USAirways training facility in Charlotte, North Carolina, NTSB Staff documented the ECAM at 80 knots on takeoff with no V-speeds and no FLEX temperature inserted in the MCDU (thrust levers remained at the FLEX position and were not increased to TOGA). At 80 knots, the aural "Retard" alert was heard. Once thrust was increased to the TOGA detent, the alert was silenced.[143]

According to Airbus, in addition to setting TOGA in response to the ECAM alert ENG THR LEVERS NOT SET as a mean to silence the alert, the "Retard" aural alert on takeoff was not associated with any Master Warning or Caution, and could be silenced via a rejected takeoff (RTO) or with the EMER CANCEL pushbutton, designed to delete spurious audio alerts and cautions.

On June 3, 2013, the USAirways Fleet Captain and Director for the Airbus fleet, sent a memo to all USAirways Airbus A319/320/321 pilots entitled "Flex Takeoff" that stated the following:[144]

> *Recently we have experienced a number of unnecessary Rejected Takeoff's because a FLEX temperature was omitted in the MCDU when intending to depart with FLEX thrust. As you are aware, if a FLEX temperature is not entered in the MCDU and the thrust levers are positioned to FLEX, a warning will be triggered. Alone, this is not a requirement for a rejected takeoff; simply continue to advance the thrust levers to TOGA and continue the takeoff.*
>
> *Please review the procedures for Setting Takeoff Thrust are outlined in the Pilot Handbook in section 2d.1.2.*
>
> *After reviewing all the pertinent information in the Pilot Handbook regarding Setting Takeoff Thrust, please feel free to contact Airbus Flight Training & Standards should you have further questions.*

The Airbus Fleet Director at USAirways told NTSB staff he sent the message to the pilots after the Safety department brought the reject concerns to his attention through a Safety Preflight article following two previous events in the summer of 2013, and he wanted to emphasize the procedures that were in the manuals with regards to setting takeoff thrust. He was never aware

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[143] See Attachment 12 – CLT Simulator Test.
[144] See Attachment 13 – Flex Takeoff Memo.

of a “Retard” aural alert on takeoff until the Safety Preflight article when he was made aware that one of the rejects had a “Retard” aural alert on the takeoff, but he found it “difficult to understand how to get into that situation with the barriers they had.” He did not include anything in his note about the “Retard” aural alert on takeoff because there was nothing in the Flight Crew Operating Manual (FCOM) or TM that the “Retard” aural alert on takeoff was a possibility that he could reference. He did not remember communicating with Airbus about the “Retard” alert on takeoff.[145]

According to interviews conducted for the investigation, none of the A320 line pilots or A320 Check Airmen interviewed by the NTSB had ever heard that a “Retard” alert could occur on takeoff prior to the AWE1702 accident.

In June 2013, the USAirways Safety Department published a “Safety Preflight” that included an article entitled “Rejected Takeoff Events,” which stated in part:

> *In the last 3 months, the ERC [Event Review Committee] has noticed several Rejected Take-offs (RTO’s) occurring in the Airbus fleet that were a result of the thrust levers being set at MCT/FLEX without having the FLEX temp inserted in the MCDU. This triggered either an ENG FLEX TEMP NOT SET or ENG THRUST LEVERS NOT SET ECAM message. In one event, the crew continued through 80 kts and received an audible “Retard, Retard, Retard” that resulted in a High Speed RTO. The following are two examples of those reported events:*
>
> ***Event 1 -** After accomplishing the "Taxi Check" on a short taxi to the departure Runway 15R, ATC issued a new clearance to runway 15L. The FO changed the departure runway to 15L and manually reentered the takeoff performance data utilizing the TPS. By mistake, the Flex Temp was omit-ted. The thrust for a Flex Takeoff was applied and they had a brief ECAM master caution and ECAM message that went away very quickly. Neither pilot could read what the warning was before it went away. This occurred prior to 80kts. At approximately 80 KIAS the crew got an aural message, “Retard, Retard, Retard”. The crew aborted the takeoff.*
>
> ***Event 2 -** Low speed rejected T/O due to a “thrust levers not set” warning at initial thrust setting. At initial warning the Capt. assessed and his initial thought was that it was a thrust reverser warning; he rejected the T/O to further assess. The message went away after reject, but after discussion the crew realized it was caused by the MCDU being set for a TOGA T/O while the flying pilot had inadvertently set Thrust levers to FLEX.*
>
> *For more information, please take time to review the guidance for Setting Takeoff Thrust in the Pilot Handbook section 2d.1.2.* [146]

15.9.3.1 Flight Operations Standards Board (FOSB)

[145] See Attachment 1 – Interview Summaries.
[146] See Attachment 14 – Safety Preflight Article.

According to the USAirways Director of Fight Technical Operations, USAirways had a FOSB that was comprised of himself, the Vice President of Flight Operations, the Managing Director of Operations Safety, the Regional Director of Phoenix, the International Regional Director in Philadelphia, the Director of Safety and Regulatory Compliance, the Managing Director of Flight Training and Standards, the fleet captains from the Boeing, Airbus and Embraer fleets, and the Managing Director of Flight Operations Policies and Procedures. The FAA Principal Operations Inspector (POI) and Vice President of Safety and Regulatory Compliance were also two non-voting advisory members. The FOSB group would typically meet on a monthly basis, but were recently meeting on a weekly basis to discuss merger related issues. According to the USAirways Vice President Safety, the FOSB would take recommendations from the Flight Data Analysis Group (FDAG), which was made up of the same representatives as the FOSB (including USAPA), on changes to training or procedures based on a trend analysis of data from FOQA, AQP, LOSA and Flight Irregularity Reports (FIRs).

According to the USAirways Airbus Fleet Director, the "Retard" aural alert on takeoff for the Airbus was never discussed in the FOSB meetings. The USAirways Managing Director of Flight Technical Operations also did not get any information regarding the "Retard" aural alert on takeoff through the FOSB.[147]

The POI stated that he attended the FOSB meetings in the past when he was an Assistant POI (APOI), but more recently the APOIs would attend. The FAA A320 Aircrew Program Manager (APM) said he did not participate in the FOSB since it was a "level above me." He [POI] further said the APOI would brief him on information learned at the FOSB, but he did not get a briefing regarding rejects from the FOSB meeting last year [2013].[148]

15.9.4 Airbus Guidance on "Retard" Alert

On December 27, 2013, Airbus published a "WISE" technical article (reference engsup-1686) entitled "Flight Warning Computer (FWC) - RETARD call-out during T.O. acceleration." The article stated the following:

> *The auto call out "RETARD" is normally triggered on landing phase (flight phase 8) when the following conditions are gathered:*
>
> - *aircraft speed is above 80kts,*
> - *AND both thrust levers are not set to idle,*
> - *AND TOGA or FLEX MODE not engaged (GO AROUND operation).*
>
> *However, a call out "RETARD" may be unduly generated during TO roll due to a wrong flight phase computation by the FWC. Wrong flight phase computation may be due to an abnormal thrust setting (i.e. no engines recognized at TO power by the FWC).*

[147] The Managing Director of Flight Technical Operations further said that had he got the information regarding the "Retard" aural alert on takeoff, the first thing he would have done was to bring that to the FOSB meeting and discuss it. If there was a need to do a safety risk analysis, they would look to see if they needed to modify procedures. See Attachment 1 – Interviews Summaries.
[148] See Attachment 1 – Interview Summaries.

Flight phase 2 is computed as soon as one engine is started.
Flight phase 3 is calculated whether one or another TLA is at "TO POWER" condition
Flight phase 4 is calculated if A/C speed is > 80 kts.

Logics for triggering "TO POWER" condition of the engines depend on the type of TO realised:

- *for a normal TO: Thrust Lever Angle (TLA) is at TOGA position (i.e. above 43.3 degrees) OR N1 is above 95%*
- *for a FLEX or DERATED TO: TLA is at MCT position (i.e. from 33.33 to 36.67 degrees)*

So, if the take-off is initiated with an abnormal thrust setting (i.e. no engines at TO power), during the acceleration phase, FWC stay in flight phase 2 and does not enter into flight phase 3 because of too low TLA and too low N1. When over 80 kts, the FWC leaves the flight phase 2 for excessive speed and computes the flight phase 8 corresponding to a landing roll.

The "RETARD" call out is therefore triggered at around 80 kts. Please note that the "RETARD" call out is NOT associated with Master Caution or Master Warning lights. This scenario can be confirmed by DFDR data analysis with N1 and thrust lever position parameters. Similar events were confirmed by other operators through data analysis.

Hence the "RETARD" call out experienced during TO roll is supposed to be linked to a wrong aircraft flight phase computation by FWCs due to throttles position not set in TO POWER condition (TO/GA or FLX/MCT TLA positions). Finally, if confirmed, this FWC behavior does not correspond to a failure but is a normal operation due to the TLA configuration. So, there is no troubleshooting procedure to be applied at FWC level.

A chart depicting the A320 flight phases was found in the USAirways A318/A319/A320/A321 FCOM, Auto-flight – General (Warnings and Cautions), page 7/10 (provided to the NTSB by Airbus).

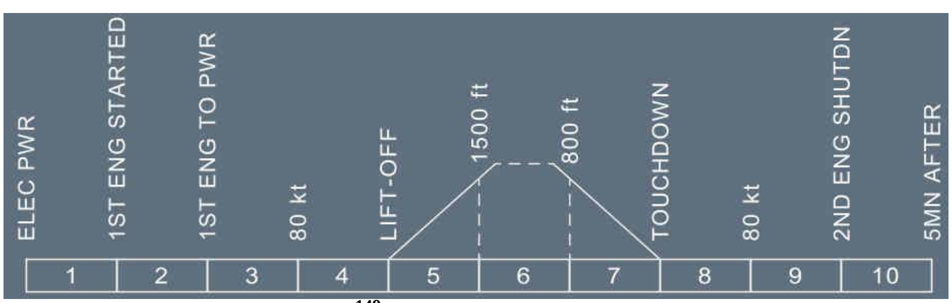

Figure 17: A320 Flight Phases.[149]

[149] Source: USAirways A318/A319/A320/A321 Flight Crew Operating Manual (FCOM), Auto-flight – General (Warnings and Cautions), page 7/10, provided to the NTSB by Airbus.

According to Airbus, WISE was a service providing specific knowledge capitalized and analyzed by Airbus, through In-Service Information ISI (ISI has since replaced the previous WISE articles) and TFU (Technical Follow-Up) articles. The information was based on in-service events, operators' and suppliers' experience, and lessons learned (flight tests, laboratory, etc.).

WISE articles were directly published and accessible online to all Airbus operators via AirbusWorld.

Operators could find the articles either by using the AirbusWorld portal search or by referring to the index (updated monthly). They could subscribe to notifications in order to be informed by mail of the publication of new or revised articles. The article on the "Retard" alert was published on December 27, 2013, and was available to all Operators.

15.10 Rejected Takeoff

According to the USAirways A319/320/321 PH, Section 2d.6.5 Maneuver, the captain was responsible for calling for and executing a rejected takeoff.

USAirways trained their captains to have their hand on the thrust levers for takeoff, and remove their hand once the V_1 call was made by the PM When alerted to the non-normal situation prior to the V_1 call, the captain would call "Reject, My Aircraft" while closing the thrust levers, engaging reverse thrust, and immediately applying maximum wheel braking using autobrakes or manual braking.[150]

According to the USAirways A319/320/321 PH, Section 2d.6.4 Recommended Guidelines, and interviews with USAirways A320 check airmen, below 80 knots on takeoff was considered the "low speed regime," and USAirways recommended a rejected takeoff for items such as engine failure, fire or fire warnings, or inability to develop rated takeoff thrust without exceeding engine limits, unusual noise or vibration, tire failure, amber MASTER CAUTION light, abnormally slow acceleration, or the perception the airplane is unsafe or unable to fly. Between 80 Knots and V1 was considered "high speed regime," and US Airways recommended a rejected takeoff for items such as engine failure, aircraft aural fire warning, or the perception the aircraft is unsafe or unable to fly.

The USAirways A319/320/321 PH, Section 2d.6.5 Maneuver, stated the following:

> *The captain will make the decision to reject the takeoff and must always be mentally and physically prepared to do so if conditions warrant. He should have his feet in position to apply the brakes and hand ready to retard the thrust levers. If the FO is PF, the captain will replace the FO's hand on the thrust levers after the thrust levers are set in the proper detent. As the aircraft accelerates towards V1, the decision-making process shifts in favor of the "Go" decision.*

[150] Source: USAirways A319/320/321 PH, Section 2d.6.5 Maneuver.

As airspeed approaches V_1, the stopping margin decreased until after V_1 when it may not be possible to stop the aircraft on the runway. The decision to reject the takeoff must be made prior to V_1 so that the rejected takeoff (RTO) maneuver could be initiated no later than V_1.

The USAirways A319/320/321 PH, Section 2d.6.1 V_1, defined V1 as follows:

V1 is the maximum speed to which an aircraft can accelerate, lose an engine, and either stop or takeoff in the remaining distance. The V1 calculation is based on a dry, hard surfaced runway, without using reverse thrust.[151]

The captain said in his statement following the accident that after the airplane became airborne he "had the perception the aircraft was unsafe to fly and I decided the safest action was to not continue." He further told NTSB staff that he rotated at about 159 knots, and when the airplane became airborne, "I felt like the airplane was totally unsafe to fly." He said everything was normal except the chime and "Retard" aural alert, and the airplane tracked down the runway normally. When he rotated, the mains came off the ground fine and the initial pitch felt fine.

According to interviews with USAirways Flight Training and Standards managers and A320 check airmen, rejected takeoffs prior to V1 were regularly trained in the simulator during initial (Qualification) and recurrent (Continuing Qualification – CQ) training. According to USAirways check airmen, rejecting a takeoff once airborne was not trained, and there were no USAirways procedures to cover an airborne rejected takeoff.

The Airbus Flight Operations Briefing Notes "Takeoff and Departure Operations - Revisiting the "Stop or Go" Decision" stated the following:

> *If a failure occurs when the aircraft speed is above V1, the only actions should involve gear up selection and audio warning cancellation, until:*
>
> - *The appropriate flight path is stabilized*
> - *The aircraft is at least 400 ft AGL.*
>
> *The objective is first to stabilize the flight path, and then to initiate the abnormal procedure without excessive delay. A height of 400 ft is recommended, because it is usually equivalent to the time it takes to stabilize the aircraft flight path.*
>
> *In some emergency conditions (e.g. engine stall, engine fire), as soon as the appropriate flight path is established, the PF may initiate actions before reaching 400 ft AGL.*

[151] According to 14 CFR 1.2, V_1 is the maximum speed in the takeoff at which the pilot must take the first action (such as applying brakes, reducing thrust, or deploying speed brakes) to stop the airplane within the accelerate-stop distance, which is a calculated distance defined in 14 CFR 25.109. V1 is also the minimum speed in the takeoff at which, after a failure of an airplane's critical engine, the pilot can continue the takeoff and achieve the required height above the takeoff surface within the takeoff distance. According to 14 CFR 25.107, V2 is the takeoff safety speed that must provide at least a minimum specified climb gradient in the event of a loss of power in one engine.

A USAirways A320 check airman told NTSB staff that the current year's A320 recurrent CQ started with the FO as PF, and they gave the crew a fire indication at 100 knots. The captain would perform the reject maneuver since it was the captain's decision whether or not to reject. They did not teach the FOs to call for a reject, and they were taught that anyone who noticed an abnormal to call it out, and the captain made the reject.[152]

15.10.1 Go/No-Go Concept

The USAirways A319/320/321 PH, Section 2d.6.3 "Go/No Go Decision" stated the following:

> *The captain must make the "Go/No Go" decision based on all available information.*

The USAirways A319/320/321 PH, Section 2d.6.5 "Maneuver" stated the following:

> *As the aircraft accelerates towards V1, the decision-making process shifts in favor of the "Go" decision. As airspeed approaches V1, the stopping margin decreases until after V1 when it may not be possible to stop the aircraft on the runway. The decision to reject the takeoff must be made prior to V1 so that the rejected takeoff (RTO) maneuver can be initiated no later than V1.*

The captain told NTSB Staff that above 80 knots, the decision process was more toward the go decision, and above 80 knots, a rejected takeoff was limited to engine fire or failure, or if the airplane was unsafe to fly. He further said they were well above 80 knots when the lack of V-speeds and "Retard" message occurred, and he already knew the takeoff numbers from their previous brief [takeoff data for 27R] so he did not see any point in rejecting for that.

The USAirways A319/320/321 PH, Section 2d.6.3 had the following note:

> *NOTE: Above 80 knots, US Airways does not recommend rejecting a takeoff solely for illumination of the amber MASTER CAUTION light or nose gear vibration.*

According to the USAirways A319/320/321 PH, 2d.6.3 "Go/No Go Decision", the ECAM inhibited the warnings/cautions which were not paramount from 80 knots to 1500 feet AGL (or 2 minutes after lift-off, whichever occurs first).[153] The following items were not inhibited when the ECAM "TO INHIBIT" memo was displayed:

> •*ENGINE FIRE*
> •*APU FIRE*
> •*ENG FAIL (ENGINE SHUT DOWN)*
> •*ENG OIL LO PR*
> •*ENG REV UNLOCKED*
> •*L + R ELEV FAULT*
> •*AP OFF (AP is not engaged for takeoff. Therefore, AP OFF warning should never occur)*

[152] See Attachment 1 – Interview Summaries.
[153] See also Attachment 19 – A320 Warnings and Cautions.

•CONFIG
•FWC 1 + 2 FAULT (without aural warning or caution light)
•PWS caution or warning (inhibited at 100 knots)

According to interviews with USAirways check airmen and pilots, and a review of the USAirways A320 training syllabus, rejected takeoffs are regularly trained during initial (Qualification) and recurrent (Continuing Qualification) simulator training. The USAirways A320 Qualification Syllabus (Simulator Session T-4) stated the following:

Rejected Takeoff/EVAC Procedures PH 2d.6 Rejected Takeoff:

- *Prior to 80 knots, rejecting for most warnings, cautions or alerts would be appropriate*
- *Reject decisions must be made early enough to ensure that the reject is initiated prior to V1. As the aircraft accelerates toward V1, the decision-making process shifts to the "go" decision.*
- *A <u>WARNING</u> from the Flight Warning Computer System on takeoff is sufficient to reject a takeoff prior to V1.*

15.10.2 No V-speeds

According to the USAirways A319/320/321 PH, Section 2d.6.2 "Go/No Go Concept," to compensate for reaction time, the PM must call "V1" five knots before V1, and the Captain must recognize the command and respond in a timely manner. The FO told NTSB Staff that she noticed there were no V-speeds depicted on the PFD at about 120-140 knots, and she could not call V1 or VR during the takeoff.[154] She further said she "assumed he wouldn't continue to takeoff if he did not know the V-speeds." She was not aware of anything that recommended rejecting or continuing a takeoff when there were no V-speeds, and according to her interview, the Captain told her "we'll continue and take care of it in the air."[155]

The captain said he had only done a reject in the simulator, usually associated with an engine fire above 80 knots but prior to V1. He also stated that he had trained on rejects above 80 and prior to V1, but never had to execute one on the line. When he did the rejects in the simulator, it "always ended up being fine."[156]

An A320 Check Airman told NTSB staff that he had never seen anyone take off without V-speeds, it was not trained, and if there were no V-speeds he would expect a crew to reject the takeoff, and then taxi off the runway. The USAirways Airbus Fleet Director told NTSB staff that the airline's expectations for a pilot confronted with no V-speeds would mean that they did not finish their checklist, and they should not have taken an active runway. The USAirways FAA Aircrew Program Manager told NTSB staff that he had never seen a situation on the line or

[154] According to the FO's interview, she indicated further that there were no other callouts that she made for the takeoff, and did not make the "80" knot callout. According to a USAirways A320 Check Airman, the 80 knot callout was used to make sure both pilots were in the loop, and also as an airspeed check for both pilots of all three airspeed indications.
[155] See Attachment 1 – Interview Summaries.
[156] See Attachment 1 – Interview Summaries.

in the simulator where a pilot initiated a takeoff roll with no visible V-speeds on the PFD, and the lack of visible V-speeds on the PFD during the initial takeoff roll would be consistent with their reject criteria, and would probably be a reason not to begin the takeoff roll in the first place since the V-speeds were supposed to be confirmed prior to takeoff. The USAirways Managing Director of Flight Technical Operations told NTSB staff he never experienced a situation where he did not have V-speeds on takeoff, and "I wouldn't dream of taking off without V-speeds."[157]

15.10.2.1 Rejected Takeoff Actions & Callouts

USAirways A320 crew actions and callouts for a rejected takeoff were found in the USAirways A319/320/321 PH, Section 2d.7 Rejected Takeoff Actions & Callouts.[158]

Rejected Takeoff	
Captain	**First Officer**
"Reject, My Aircraft"	**"Your Aircraft"**
• Retard thrust levers to IDLE	
• Use Autobrakes MAX or maximum manual braking	
• Select and maintain maximum reverse thrust until it can be assured the aircraft can stop on the runway[1]	• Monitor autobrakes **"No Autobrakes,"** if applicable • Monitor deceleration throughout reject • Notify tower, when able **"80"**
• Maintain slight forward pressure on sidestick	
As soon as aircraft is stopped	
• After immediately evaluating situation: • Make a PA announcement: **"This is the captain, remain seated."** • Advise cabin of intentions when able	
or	
• Call for and accomplish QRH Evacuation checklist	• Accomplish QRH Evacuation checklist, if directed
•Check brake temperature indication	

1. In case of complete loss of braking, accomplish "Loss of Braking" procedure in the Pilot Handbook Chapter 2i.
The distance required to decelerate from a given speed at the high weights associated with takeoff is significantly greater than from the same speed at a typical landing weight.

Figure 18: USAirways A320 Rejected Takeoff actions and callouts.[159]

[157] Airbus was asked by the NTSB to research operator reports of departing without V-speeds and had only four reports. Two crews decided to perform an RTO, and one decided to continue. Airbus was not informed on the course of actions for the last occurrence, and considered the information too limited to draw any conclusions.
[158] For additional information, see Attachment 7 – A320 Standard Operating Procedures.
[159] Source: USAirways A319/320/321 PH, Section 2d.7 Rejected Takeoff Actions & Callouts.

15.10.3 Airbus RTO Guidance

Airbus used 100 knots as "high/low" speed regime criteria for rejected takeoff considerations. The USAirways A318/319/320/321 FCOM, page AO-020 P 2/24 (provided to the NTSB by Airbus) stated in part:

> *A rejected takeoff is a potentially hazardous maneuver and the time for decision-making is limited. To minimize the risk of inappropriate decisions to reject a takeoff, many warnings and cautions are inhibited between 80 kt and 1500 ft. Therefore, any warnings received during this period must be considered as significant.*
>
> *To assist in the decision making process, the takeoff is divided into low and high speeds regimes, with 100 kt being chosen as the dividing line. The speed of 100 kt is not critical but was chosen in order to help the Captain make the decision and to avoid unnecessary stops from high speed:*
>
> - *Below 100 kt, the Captain will seriously consider discontinuing the takeoff if any ECAM warning/caution is activated.*
>
> - *Above 100 kt, and approaching V1, the Captain should be "go-minded" and only reject the takeoff in the event of a major failure, sudden loss of thrust, any indication that the aircraft will not fly safely, any red ECAM warning, or any amber ECAM caution listed below:*
>
>   - *F/CTL SIDESTICK FAULT*
>   - *ENG FAIL*
>   - *ENG REVERSER FAULT*
>   - *ENG REVERSE UNLOCKED*
>   - *ENG 1(2) THR LEVER FAULT*

According to the USAirways Airbus Fleet Director, the airline was aware that Airbus high/low speed regime guidance was 100 knots, Airbus had no objection to the airline's use of 80 knots, and the Airbus FCOM stated that the 100 knots speed was not systems related and only a dividing line between low and high speed regime to assist the captain in making a reject decision. The USAirways Managing Director of Flight Technical Operations told NTSB staff that the decision to use 80 knots was made by the FOSB for fleet commonality.[160]

Airbus provided additional guidance on rejected takeoffs in its Flight Operations Briefing Notes "Takeoff and Departure Operations - Revisiting the "Stop or Go" Decision" which stated:

> *8% of RTOs are performed at high speed (above 100 knots), and 92% are performed at low speed (below 100 knots) (Source: IATA STEADES Safety Trend Analysis - 2002). Low speed RTOs are simple maneuvers, associated with low risks, and rarely lead to runway excursions or to runway overruns.*

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[160] For additional information on the FOSB, see Section 15.9.3.1 Flight Operations Standards Board (FOSB) of this Factual Report.

High speed RTOs, on the other hand, involve difficult maneuvers, that are associated with high risks due to the amount of energy involved, and the necessity to effectively control aircraft braking and the aircraft trajectory on the runway centerline. Runway overruns or excursions mainly occur during high speed RTOs.

More than half runway overruns or excursions have statistically occurred when the RTOs have been initiated at a speed greater than V1 (Figure 1). Thus, the STOP or GO decision has to be made reaching V1; in other words, at the V1 callout at the latest. This emphasizes the importance of this callout.

The statistics and experience have shown that, as soon as the aircraft reaches 100 knots, the safest course of action is for the flight crew to continue the takeoff, unless a major failure or a serious situation occurs. Moreover, experience has shown that if RTOs are performed when the takeoff distance is ASD-limited (Acceleration-Stop Distance), and if the takeoff is rejected at V1, the consequences could be hazardous even if the performance is correctly calculated.

To minimize the risk of inappropriate decisions to reject a takeoff, the ECAM system inhibits non-relevant warnings and cautions during the high speed regime. Therefore, the Captain must immediately consider all ECAM warnings/cautions that trigger during this segment.

15.11 Evacuation

According to the accident crew interviews, when the airplane came to a stop, the captain told the passengers to remain seated. Both pilots smelled smoke, and saw that number one fire switch (left engine) was illuminated. At 1825:52, AWE1702 contacted the ATC control tower and asked “do you show smoke coming out of the ah left engine?”

The captain told NTSB staff he asked the tower if they saw smoke, and when they said yes, he fired the agent in the left engine, shut down the engines, called for the evacuation checklist and evacuated the airplane. The captain said he only fired the one bottle in the left engine while talking to tower. He further said that while the FO was getting her glasses, he ran the checklist including the FO items on the checklist. The FO stated the captain called for the evacuation using the PA system after they found out the tower said the smoke was bad.[161]

The USAirways A319/320/321 PH, Section 9.1 "Non-Normal Methodology,” stated:

When evacuation of the aircraft is required, all necessary actions are included in the Evacuation Checklists. Other checklists need not be referenced. Each crewmember reads aloud and accomplishes the Evacuation Checklist immediate action items simultaneously. If one crewmember must accomplish the entire checklist, read aloud and accomplish immediate action items in order from beginning of checklist.

[161] See Attachment 1 – Interview Summaries.

The USAirways FOM, page 4-6 stated:

> *The decision to evacuate must be based on an objective evaluation of a real threat, as opposed to a subjective evaluation of a perceived threat to the safety of passengers and crew.*
>
> ***Captain Initiated Evacuation.*** *Once the decision is made, complete the Evacuation Checklist and make the evacuation announcement:*
> ***This is the captain. Evacuate, evacuate.***
> *Remove all passengers to a point well clear of the aircraft, out of range of possible fire or explosion.*
> *Do not allow passengers to return to the aircraft until danger no longer exists.*
>
> ***Flight Attendant Initiated Evacuation:*** *In non-normal situations, if no flightdeck crew member has provided the necessary direction, flight attendants will attempt to contact the flightdeck either by interphone or in person. Flight attendants may initiate an evacuation if the passengers are in imminent danger only under the following conditions:*
> *— severe structural damage*
> *— threatening fire or smoke*
> *— no response from the flightdeck*

15.11.1 Evacuation Checklist

According to the USAirways A319/320/321 QRH front cover, the evacuation checklist contained the following duties:

> *First Officer:*
> *1. PARK BRK .... Check ON*
> *2. ATC (VHF-1) ....Notify*
> *3. If MAN CAB PR is in use:*
> *a. MAN V/S CTL.. Full UP*
> *4. First Officer Evacuation checklist complete, time permitting, go to page 35.*
>
> *Captain:*
> *1. PARK BRK .... ON*
> *2. ENG MASTER 1 and 2... OFF*
> *3. FIRE pbs (ENG and APU) .... PUSH*
> *4. AGENTs (ENG and APU) (if required).................. .DISCH*
> *5. PA .... This is the captain. Evacuate, evacuate.*
> *6. Captain Evacuation Checklist complete, time permitting, go to page 35.*

16.0 FAA Oversight

FAA oversight of the USAirways certificate was conducted from the Eastern Region (EA19) USAirways Certificate Management Office (CMO) near Pittsburgh in Moon Township, Pennsylvania.

Within the CMO, they had a manager of the office, assistant manager, and three principal inspectors; a Principal Avionics Inspector (PAI), a Principal Maintenance Inspector (PMI), and a Principal Operations Inspector. There were also two Assistant POI's. Each fleet had an Aircrew Program Manager (APM), and the A320 APM had an Assistant APM. There were several Remotely Sited Inspectors (RSI); one located at the training center in CLT, one in Columbus, Ohio (leftover from the America West certificate) and one in PHL.

According to the POI, he was responsible for assigning their duties, certification and surveillance through the Air Transportation Oversight System (ATOS), and oversaw their data programs like ASAP, FOQA, and ATOS. He used the ATOS to assist in his duties for surveillance, as well as the handbook guidance for national policy, and information was tracked in the PTRS system.

The POI told NTSB Staff he was aware of the June 2013, memo from the Airbus Fleet Captain to Airbus pilots entitled "Flex Takeoff" that also described recent rejects, but it did not mention any "Retard" alert, and he was not aware if the airline conducted follow up research on why the "Retard" alert came on during one of the rejects.

According to the POI, there had not been a lot of changes on the Airbus fleet since American Airlines was bringing on the Airbus and had adopted the USAirways procedures. The biggest challenges were changes to the crews. The changes were staggered, based on phases of flight, and they were making adjustments to the manuals and training. They had 9 revision cycles, entering into revision cycle 6, and those changes were being made and analyzed to see if everything was going according to plan. He got feedback from the program managers regarding what the pilots saw as concerns. He did not see a whole lot of large issues or problems. He thought that USAirways had a good safety culture and a strong program, and Threat and Error Management (TEM) was integrated throughout their program, and characterized their AQP program as "good."[162]

The A320 APM oversaw the training and certification of the airmen, check airmen and Aircrew Program Designees (APDs) on the A320 fleet. USAirways had 21 APDs on the A320; 13 were in CLT and 8 were in PHX. The bulk of the A320 training at USAirways was conducted in CLT. The A320 APM conducted APD meetings annually, with the last meeting occurring in November of 2013. The APM told NTSB staff that they did not talk about any of the issues associated with the rejects from the past summer at the November 2013 meeting "because it did not seem like an issue at the time."[163]

The APM told NTSB staff that he probably read the June 2013 Safety Preflight article that discussed a recent reject, and included information about a "Retard" aural alert, but he did not remember it. He did not believe there was any discussion within the training department about the "Retard" aural alert coming on during one of the previous rejects, and first became aware of the aural "retard" message on takeoff in March of 2014. He did not remember seeing any information on the subject from Airbus.

[162] See Attachment 1 – Interview Summaries.
[163] See Attachment 1 – Interview Summaries.

F. ADDITIONAL INFORMATION

17.0 High-Speed Rejected Takeoffs Study

In 1990, the NTSB issued a special investigation report (SIR), *Runway Overruns Following High Speed Rejected Takeoffs*[164] that examined high-speed RTOs involving commercial jet airplanes. The SIR reviewed three studies, which included data from the NTSB, the National Aeronautics and Space Administration, and Boeing, related to the causes and outcomes of RTOs. The SIR found that tire failures led to more high-speed RTOs than engine-related anomalies.

The Boeing study reviewed in the SIR analyzed data on RTO-related incidents and accidents from 1959 to 1988 and found that that many of the RTOs were initiated after V1 and that more than half of the RTOs were unwarranted. The study found that the airplanes should have been able to continue the takeoff without incident. Since the time that the SIR was published, Boeing updated its review to include a total of 94 RTO-related accidents or incidents from 1959 to 1999 (74 from 1959 to 1990, and 20 from 1991 to 1999).[165]

18.0 Advisory Circular 120-62

In 1994, the FAA published Advisory Circular (AC) 120-62, *Takeoff Safety Training Aid*, to provide guidance to "minimize, to the greatest extent practical, the probability of RTO-related accidents and incidents." The AC, which applies to Part 121 operators, states that "many of the principles, concepts, and procedures described apply to operations under [14 CFR] Parts 91, 129, and 135 for certain aircraft, and are recommended for use by those operators when applicable." The AC provides recommended elements for air carrier ground training programs that state, in part, that the training should:

> *…ensure thorough crew awareness in at least the following topics: (1) Proper RTO and takeoff continuation procedures in the event of failures; (2) Potential effects of improper procedures during an RTO, (3) Guidelines on rejecting or not rejecting a takeoff in the low and high speed regimes; (4) Assigned crewmember duties, use of comprehensive briefings, and proper crew coordination.*

The AC also provides recommended elements for air carrier flight training programs and pilot evaluations that state, in part, that simulator scenarios should include the following conditions and procedures: "demonstration of the proper and appropriate crew responses for engine failure, tire failure, nuisance alerts, and critical failures that affect the ability to safely continue the takeoff in both the high and low speed regimes."

Section 2 of AC 120-62, "Pilot Guide to Takeoff Safety," addressed various aspects of the go/no-go decision-making process in response to various anomalies and provided the following cautions:

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[164] National Transportation Safety Board, *Runway Overruns Following High Speed Rejected Takeoffs*. Special Investigation Report SIR-90-02 (Washington, DC: NTSB, 1990).
[165] This information was obtained from Boeing's website <http://www.boeing.com/commercial/aeromagazine/aero_11/takeoff_reasons.html> (accessed October 1, 2014).

The infrequency of RTO events may lead to complacency about maintaining sharp decision making skills and procedural effectiveness. In spite of the equipment reliability, every pilot must be prepared to make the correct Go/No Go decision on every takeoff--just in case.
Do not attempt an RTO once the airplane has passed V1 unless the pilot has reason to conclude the airplane is unsafe or unable to fly. This recommendation should prevail no matter what runway length appears to remain after V1.

19.0 Advisory Circular 120-71A

AC 120-71A provided background, basic concepts and philosophy in respect to SOPs. SOPs are universally recognized as basic to safe aviation operations. Effective crew coordination and crew performance, two central concepts of crew resource management depended upon the crew's having a shared mental model of each task. That mental model, in turn, was founded on SOPs. This AC emphasized that SOP's must be clear, comprehensive, and readily available in the manuals used by flight deck crewmembers. A comprehensive SOP template was provided in the AC.

20.0 Safety Alert for Operators (SAFO) 06013

The purpose of this SAFO was to provide techniques, procedures and items for consideration in training programs that emphasize safe operations in the pre-takeoff and takeoff phases of flight.

21.0 SAFO 07003

This SAFO emphasized the importance of implementing standard operating procedures and training for flight crews to ensure that an airplane is at the desired takeoff runway, and to recommend some modern resources and procedures for doing so. This SAFO expanded upon information initially published in SAFO 06013, by taking particular note of modern resources not previously available to pilots when attempting to positively confirm and cross-check the takeoff runway. Some of these resources were in the airplane, others are not.

22.0 Past Recommendations

22.1 Accident ID: DCA08MA098

On September 19, 2008, about 2353 eastern daylight time, a Bombardier Learjet Model 60, N999LJ, owned by Inter Travel and Services, Inc., and operated by Global Exec Aviation, overran runway 11 during a rejected takeoff at Columbia Metropolitan Airport, Columbia, South Carolina.1 The captain, the first officer, and two passengers were killed; two other passengers were seriously injured. The nonscheduled domestic passenger flight to Van Nuys, California was operated under 14 Code of Federal Regulations (CFR) Part 135. Visual meteorological conditions prevailed, and an instrument flight rules flight plan was filed.

Recommendation A-10-056
TO THE FEDERAL AVIATION ADMINISTRATION: Once the simulator model fidelity

requirements requested in Safety Recommendation A-10-55 are implemented, require that simulator training for pilots who conduct turbojet operations include opportunities to practice responding to events other than engine failures occurring both near V1 and after V1, including, but not limited to, tire failures. Status: Closed unacceptable action.

22.2 Accident ID: DCA92MA044

On July 30, 1992, at 1741 EDT, Trans World Airlines (TWA) flight 843, an L-1011, N11002, experienced an aborted takeoff shortly after liftoff from John F. Kennedy International Airport, Jamaica, New York, enroute to San Francisco International Airport, California. The airplane came to rest, upright and on fire, on grass-covered soil, about 290 feet to the left of the departure end of runway 13R. There were no fatalities among the 280 passengers on board the airplane, but there were 10 reported injuries that occurred during the emergency evacuation. The flight was operating under 14 Code of Federal Regulations Part 121.

Recommendation A-93-049
The National Transportation Safety Board recommends that the FAA: Issue an air carrier operating bulletin directing Principal Operations Inspectors for 14 CFR and 14 135 airlines to include in the training and procedures a requirement for crew coordination briefings on actions to take in the event of abnormal situations during the takeoff and initial climb phase of flight, and the proper techniques for the transfer of control of the airplane, especially during time-critical phases of flight. Status: Closed acceptable action.

23.0 Post-accident Safety Actions

23.1 CBS Message

On March 27, 2014, the USAirways Director Airbus Flight Training and Standards sent a CBS[166] message to all USAirways pilots entitled "Changing Takeoff Runway." The CBS message stated the following:

> *Prior to takeoff, if the takeoff runway is changed on the F-PLN page, the message "CHECK TAKEOFF DATA" is displayed in the scratchpad. Like all scratchpad messages, this should be carefully read and assessed. This message is a reminder to adjust or confirm the takeoff data on the PERF TAKEOFF page. It is then necessary to select the PERF page to view the takeoff data. The previous data (V1, VR, V2 FLX TO values) appear in small, blue font beside the corresponding fields. If no data change is necessary, simply select CONFIRM TO DATA (6R). This reinserts the data in small, blue font into the corresponding fields. If changes to this data are required, uplink the performance data for the new runway or make necessary corrections manually.*
>
> *If a valid FLEX TO TEMP is not entered into the Takeoff PERF page in the MCDU, the ECAM will display the caution when the thrust levers are placed in the FLX/MCT detent:*

[166] Crew Broadcast System (CBS). According to the USAirways FOM, Section 13.5.3, The Crew Broadcast System is an electronic communication tool used to disseminate information to CLT/DCA/PHL based flight crews. See Attachment 15 – A320 CBS Message.

ENG THRUST LEVERS NOT SET
THR LEVERS . . . . TO/GA

As a reminder, the A319/320/321 Pilot Handbook, 2d.1.2 states, "If a FLEX temperature was not entered in the MCDU, and the thrust levers are positioned in the FLEX detent, a warning will be generated. In this case, move the thrust levers to TOGA detent and execute a max thrust takeoff." If TOGA is not selected, the "RETARD" aural callout is triggered when the airspeed reaches 80 knots. When the thrust levers are moved to the TOGA position, the ECAM message will clear and the aural "RETARD" will cease.

To preclude this situation, ensure barriers to error are in place by following standard operating procedures, and completing flows and checklists carefully to ensure that all necessary takeoff data is entered correctly for the takeoff runway.

23.2 Bulletin 21-14 "RETARD" Auto Callout During Takeoff

On September 5, 2014, USAirways published Bulletin 21-14 as a policy change to their A320 Pilot Handbook.[167] The bulletin stated the following:

"RETARD" Auto Callout During Takeoff

Background. *Airbus has identified the possibility to erroneously receive the auto callout "RETARD" during takeoff. This callout is generated during takeoff due to the incorrect calculation of flight phase by the Flight Warning Computers. This occurs at and above 80 knots on takeoff when the thrust levers have been placed in the FLX/MCT detent and no FLEX TEMP was entered in the MCDU PERF TO page. However, if the thrust levers are placed in the TOGA detent prior to reaching 80 knots, the "RETARD" callout does not occur.*

Procedure. *Per current Pilot Handbook procedure, if a FLEX temperature was not entered in the MCDU, and the thrust levers are positioned in the FLEX/MCT detent, an ECAM caution will be generated. In this case, move the thrust levers to TOGA detent and execute a max thrust takeoff in accordance with ECAM direction. When the thrust levers are moved to the TOGA detent, the warning will be cancelled. (See Pilot Handbook, 2d.1.2). If the thrust levers are not moved to the TOGA detent prior to 80 knots, the "RETARD" auto callout will sound. Should this occur, perform a rejected takeoff.*

The following change to Pilot Handbook 2d.6.4, Rejected Takeoff, Recommended Guidelines, will not be reflected in Revision Cycle 5, but will be included in a subsequent revision:

Between 80 Knots and V1. *US Airways recommends a rejected takeoff for items such as engine failure, aircraft aural fire warning, predictive windshear warning or caution, the occurrence of the "RETARD" auto callout, or the perception the aircraft is unsafe or unable to fly.*

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[167] See Attachment 16 - Revised RTO Policy.

G. LIST OF ATTACHMENTS

Attachment 1: Interview Summaries
Attachment 2: Crew Information
Attachment 3: Crew Statements
Attachment 4: AWE1702 Paperwork
Attachment 5: Air Traffic Control
Attachment 6: Airbus Changes Before Takeoff Presentation
Attachment 7: A320 Standard Operating Procedures
Attachment 8: Change of Departure Runway
Attachment 9: A320 Aural Indicators
Attachment 10: Toulouse, France Simulator Session
Attachment 11: ECAM Malfunction Notifications
Attachment 12: CLT Simulator Test
Attachment 13: Flex Takeoff Memo
Attachment 14: Safety Preflight Article
Attachment 15: A320 CBS Message
Attachment 16: Revised RTO Policy
Attachment 17: Party Forms
Attachment 18: AirbusWorld Article
Attachment 19: A320 Warnings and Cautions

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