# Aviation Investigation Final Report

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| **Location:** | Philadelphia, Pennsylvania | **Accident Number:** | DCA14MA081 |
| **Date & Time:** | March 13, 2014, 18:22 Local | **Registration:** | N113UW |
| **Aircraft:** | Airbus A320 - 214 | **Aircraft Damage:** | Substantial |
| **Defining Event:** | Abnormal runway contact | **Injuries:** | 154 None |
| **Flight Conducted Under:** | Part 121: Air carrier - Scheduled | | |

## Analysis

Before pushback from the gate, the first officer, who was the pilot monitoring, initialized the flight management computer (FMC) and mistakenly entered the incorrect departure runway (27R instead of the assigned 27L). As the captain taxied onto runway 27L for departure, he noticed that the wrong runway was entered in the FMC. The captain asked the first officer to correct the runway entry in the FMC, which she completed about 27 seconds before the beginning of the takeoff roll; however, she did not enter the FLEX temperature (a reduced takeoff thrust setting) for the newly entered runway or upload the related V-speeds. As a result, the FMC's ability to execute a FLEX power takeoff was invalidated, and V-speeds did not appear on the primary flight display (PFD) or the multipurpose control display unit during the takeoff roll.

According to the captain, once the airplane was cleared for takeoff on runway 27L, he set FLEX thrust with the thrust levers, and he felt that the performance and acceleration of the airplane on the takeoff roll was normal. About 2 seconds later, as the airplane reached about 56 knots indicated airspeed (KIAS), cockpit voice recorder (CVR) data indicate that the flight crew received a single level two caution chime and an electronic centralized aircraft monitoring (ECAM) message indicating that the thrust was not set correctly. The first officer called "engine thrust levers not set." According to the operator's pilot handbook, in response to an "engine thrust levers not set" ECAM message, the thrust levers should be moved to the takeoff/go-around (TO/GA) detent.

However, the captain responded by saying "they're set" and moving the thrust levers from the FLEX position to the CL (climb) detent then back to the FLEX position. As the airplane continued to accelerate, the first officer did not make a callout at 80 KIAS, as required by the operator's standard operating procedures (SOPs). As the airplane reached 86 KIAS, the automated RETARD aural alert sounded and continued until the end of the CVR recording. According to Airbus, the RETARD alert is designed to occur at 20 ft radio altitude on landing and advise the pilot to reduce the thrust levers to idle. The captain later reported that he had never heard an aural RETARD alert on takeoff, only knew of it on landing, and did not know what it was telling him. He further said that when the RETARD aural alert

sounded, he did not plan to reject the takeoff because they were in a high-speed regime, they had no red warning lights, and there was nothing to suggest that the takeoff should be rejected.

The first officer later reported that there were no V-speeds depicted on the PFD and, thus, she could not call V1 or VR during the takeoff. She was not aware of any guidance or procedure that recommended rejecting or continuing a takeoff when there were no V-speeds displayed. She further said she "assumed [the captain] wouldn't continue to takeoff if he did not know the V-speeds." The captain stated that he had recalled the V-speeds as previously briefed from the Taxi checklist, which happened to be the same V-speeds for runway 27L. The captain continued the takeoff roll despite the lack of displayed V-speeds, no callouts from the first officer, and the continued and repeated RETARD aural alert.

FDR data show that the airplane rotated at 164 KIAS. However, in a postaccident interview, the captain stated that he "had the perception the aircraft was unsafe to fly" and that he decided "the safest action was not to continue," so he commenced a rejected takeoff. FDR data indicate that the captain reduced the engines to idle and made an airplane-nose-down input as the airplane reached 167 KIAS (well above the $V_1$ speed of 157 KIAS) and achieved a 6.7 degree nose-high attitude. The airplane's pitch decreased until the nosegear contacted the runway. However, the airplane then bounced back into the air and achieved a radio altitude of about 15 ft. Video from airport security cameras show the airplane fully above the runway surface after the bounce. The tail of the airplane then struck the runway surface, followed by the main landing gear then the nose landing gear, resulting in its fracture. The airplane slid to its final resting position on the left side of runway 27L.

The operator's SOPs address the conditions under which a rejected takeoff should be performed within both low-speed (below 80 KIAS) and high-speed (between 80 KIAS and $V_1$) regimes but provide no guidance for rejecting a takeoff after $V_1$ and rotation. Simulator testing performed after the accident demonstrated that increasing the thrust levers to the TO/GA detent, as required by SOPs upon the activation of the "thrust not set" ECAM message, would have silenced the RETARD aural alert. At the time of the accident, neither the operator's training program nor manuals provided to flight crews specifically addressed what to do in the event the RETARD alert occurred during takeoff; although, 9 months before the accident, US Airways published a safety article regarding the conditions under which the alert would activate during takeoff. The operator's postaccident actions include a policy change (published via bulletin) to its pilot handbook specifying that moving the thrust levers to the TO/GA detent will cancel the RETARD aural alert.

Although simulator testing indicated that the airplane was capable of sustaining flight after liftoff, it is likely that the cascading alerts (the ECAM message and the RETARD alert) and the lack of V-speed callouts eventually led the captain to have a heightened concern for the airplane's state as rotation occurred. FDR data indicate that the captain made erratic pitch inputs after the initial rotation, leading to the nose impacting the runway and the airplane bouncing into the air after the throttle levers had been returned to idle. Airbus simulation of the accident airplane's acceleration, rotation, and pitch response to the cyclic longitudinal inputs demonstrated that the airplane was responding as expected to the control inputs.

Collectively, the events before rotation (the incorrect runway programmed in the FMC, the "thrust not set" ECAM message during the takeoff roll, the RETARD alert, and the lack of required V-speeds callouts) should have prompted the flight crew not to proceed with the takeoff roll. The flight

crewmembers exhibited a self-induced pressure to continue the takeoff rather than taking the time to ensure the airplane was properly configured. Further, the captain initiated a rejected takeoff after the airplane's speed was beyond $V_1$ and the nosewheel was off the runway when he should have been committed to the takeoff. The flight crewmembers' performance was indicative of poor crew resource management in that they failed to assess their situation when an error was discovered, to request a delayed takeoff, to communicate effectively, and to follow SOPs. Specifically, the captain's decision to abort the takeoff after rotation, the flight crew's failure to verify the correct departure runway before gate departure, and the captain's failure to move the thrust levers to the TO/GA detent in response to the ECAM message were all contrary to the operator's SOPs.

Member Weener filed a statement, concurring in part and dissenting in part, that can be found in the public docket for this accident. Chairman Hart, Vice Chairman Dinh-Zarr, and Member Sumwalt joined the statement.

## Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: the captain's decision to reject the takeoff after the airplane had rotated. Contributing to the accident was the flight crew's failure to follow standard operating procedures by not verifying that the airplane's flight management computer was properly configured for takeoff and the captain's failure to perform the correct action in response to the electronic centralized aircraft monitoring alert.

### Findings

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| **Personnel issues** | Decision making/judgment - Pilot |
| **Personnel issues** | Incorrect action performance - Flight crew |
| **Personnel issues** | Incorrect action performance - Pilot |
| **Aircraft** | Flt management computing sys - Incorrect use/operation |

# Factual Information

## History of Flight

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| **Takeoff-rejected takeoff** | Abnormal runway contact (Defining event) |
| **Takeoff-rejected takeoff** | Landing gear collapse |

HISTORY OF FLIGHT

On March 13, 2014, about 1830 eastern standard time, US Airways flight 1702, an Airbus A320, N113UW, experienced substantial damage after the captain rejected the takeoff after rotation on runway 27L at Philadelphia International Airport, Philadelphia, Pennsylvania. The airplane came to rest on the edge of the runway, and the crew and passengers exited via the emergency slides. Of the 149 passengers, 2 pilots, and 3 flight attendants on board, 2 passengers reported minor injuries related to the evacuation. The airplane was substantially damaged. The flight was operating under 14 *Code of Federal Regulations* Part 121 as a regularly scheduled passenger flight from PHL to Fort Lauderdale/Hollywood International Airport (FLL), Fort Lauderdale, Florida. Day visual meteorological conditions prevailed at the time.

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

According to crew interviews, upon arrival at the accident airplane, the first officer, who was the pilot monitoring (PM), prepared the cockpit while the captain spoke with the dispatcher. The first officer initialized the flight management computer (FMC) with the air traffic control (ATC)-provided flight plan and manually entered the departure runway into the FMC. The ATC route clearance verification procedure is defined in the US Airways standard operating procedures (SOPs) and is performed for every flight. Both pilots stated during postaccident interviews that they verified the ATC routing loaded into the FMC while still at the gate before pushback; however, neither pilot realized that the departure runway loaded into the FMC was runway 27R instead of the assigned runway 27L.

Flight 1702 pushed back from gate B8 about 1752, and the taxi out was normal. The weather reported at 1754 was clear skies and 10 statute miles visibility, temperature 0°C, dewpoint -21°C, and winds from 290° at 18 knots with gusts to 28 knots (peak winds at 1713 were recorded from 300° and 33 knots). Automatic terminal information service information "Yankee" called for runway 27L as the departure runway. Flight 1702 had been given an expect departure clearance time of 1829, and the captain decided to conduct a single-engine taxi.

At 1754:33, flight 1702 received the final weight and balance information for the flight via the aircraft communication addressing and reporting system, and according to the first officer interview, she loaded the weight and balance information into the FMC via uplink. She could not remember if she uplinked

the takeoff data or manually entered the V-speeds and FLEX (a reduced takeoff thrust setting) temperature information into the multipurpose control display unit (MCDU).

At 1808:20, flight 1702 contacted ground control for taxi instructions; the ATC ground controller advised that the departure runway was 27L and provided taxi instructions to runway 27L. At 1819:29 the tower controller advised the flight crew that they were number six for departure from runway 27L. At 1820:29, the crew started the second engine then conducted a flight control check. At 1821:22, the tower controller advised that flight 1702 would be next for departure, and the flight crew acknowledged their sequence 4 seconds later. The first officer started to read the remainder of 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 first officer stated that she continued the checklist as the captain was taxiing toward runway 27L.

At 1822:35, flight 1702 was cleared to line up and wait on runway 27L. The first officer accomplished the remainder of the Taxi checklist. As the captain taxied onto runway 27L, he noticed that runway 27R had been inserted into the FMC instead of runway 27L and requested that the first officer change the runway in the FMC, which was completed at 1823:10.

At 1823:26, flight 1702 was given a heading of 230 degrees on departure and a clearance for takeoff. Flight data recorder (FDR) data indicate that the airplane had a ground speed of 0 knots indicated airspeed (KIAS) for about 11 seconds before accelerating for takeoff. At 1823:34, the throttle levers initially advanced to the MAX CLIMB level and the captain's longitudinal control was moved to the airplane nose down (AND) direction at 1823:41. The throttles were advanced further to the FLEX detent by 1823:43, with the airplane moving about 46 KIAS. According to crew interviews and cockpit voice recorder (CVR) data, when the captain set the thrust levers in the FLEX detent at 1823:45, the crew received an electronic centralized aircraft monitoring (ECAM) message and chime at 1823:47 indicating that the thrust was not set. In response, the first officer stated "engine thrust levers not set." FDR data indicate the thrust levers were briefly reduced to the climb detent then returned to the FLEX detent about 1 second later. The captain responded "they're set" 3 seconds later.

According to FDR and CVR data, the first officer did not make a required callout as the airplane's speed reached 80 KIAS. According to flight crew interviews, the captain and first officer noticed that there were no V-speeds indicated on their primary flight displays (PFDs), and FDR and CVR data show that as the airplane accelerated through 86 KIAS as an aural RETARD alert sounded in the cockpit. According to the CVR, at 1823:56, the captain asked the first officer "what did you do, you didn't load. We lost everything." At 1824:03, as the airplane continued to accelerate through 143 KIAS, the captain stated "we'll get that straight when we get airborne" and continued the takeoff roll.

The airplane continued to accelerate over the next several seconds, reaching 152 KIAS at 1824:08. At 1824:09, the first officer stated "wh*. I'm sorry", the captain's longitudinal control was brought into the airplane nose up (ANU) direction, and the pitch of the airplane began to increase as the longitudinal control was brought up to 6.9 degrees ANU over the next second as the airplane began initial rotation for takeoff. The airspeed at this point was 164 KIAS, and the nose gear weight on wheels discrete changed to "air" by 1824:10.

Over the next 4 seconds, with the nose gear discrete reading "air" and the main landing gear discrete reading "ground" the captain's longitudinal control was pushed into the airplane nose down (AND)

direction, and then pulled back in the ANU direction two times, reaching the maximum of 16 degrees in the ANU direction, and a minimum of 16 degrees AND during the cyclic input. The pitch of the airplane, and vertical acceleration followed the variations in longitudinal inputs. As the vertical acceleration decreased in response to the nose down input, the flight crew reduced the thrust levers, and the captain's longitudinal control was pulled again in the ANU direction. The vertical acceleration reached a minimum of 0.121 G as the control was pulled to 16 degrees ANU, the maximum operational value, and the engine throttle lever angles were reduced to idle thrust where they remained for the rest of the recording.

By 1824:14, the nose gear weight on wheels discrete parameter changed back to "ground." During the previous 4 seconds, when the nose parameter recorded "air," the main landing gear (both left and right) weight on wheels parameter had recorded "ground," and the maximum radio altitude recorded was 6 feet above ground level (agl), which occurred for only 1 second. Once the pitch reduced to -0.4 degree, the vertical acceleration rapidly increased to 3.7 G, consistent with the gear impacting the runway surface. The pitch parameter was not valid for the rest of the FDR recording. As the vertical acceleration reached its maximum value, the captain's longitudinal input reached a maximum of 16 degrees ANU.

The captain's longitudinal control cycled in the nose up and nose down directions over the next 2 seconds. During this variation, the vertical acceleration dropped to 0.47 G, then increased to 1.2 G. As the longitudinal stick was pulled back to over 16 degrees ANU and held at the maximum value, the main landing gear weight on wheel parameters changed to "air" for the next 2 seconds, and the radio altitude began to increase to about 15 ft agl.

As the airplane reached 15 ft agl, the longitudinal control moved back to the AND position, and pitch of the airplane again reduced and the airplane began to descend back to the runway surface. The stick was moved again in the ANU direction as the airplane began to descend and, correspondingly, the airplane pitch increased again. Surveillance video obtained from the Philadelphia Airport captured the final impact with the runway. The video shows the airplane impacted the runway first with the tail, then main landing gear, and the airplane then rotated in the AND direction, resulting in the nose gear impacting the runway and subsequently collapsing.

At 1824:48, the flight crew advised the tower that they aborted the takeoff as the airplane came to rest on the left side of runway 27L. At 1829:14, the flight crew advised the PHL tower that they were evacuating the airplane. The flight attendants stated all slides deployed normally, except door 2R, which was not deployed due to smoke on the right side of the airplane, and 2L, which did not reach the ground due to the nose gear collapse.

## DAMAGE TO AIRCRAFT

The airplane nose gear collapsed upon impact with the paved runway, resulting in fuselage and engine cowling damage. As a result of the tailstrike, additional damage occurred to the lower aft fuselage section of the airplane, including the aft pressure bulkhead, fuselage, struts, and cross beams. Damage to the left engine occurred after the nose gear collapse due to ingestion of debris.

## PERSONNEL INFORMATION

### The Captain

The captain, age 61, was hired by Piedmont Airlines on March 3, 1986. US Airways (then USAir) purchased Piedmont Airlines in 1987 and merged operations in 1989. His background was all civilian flying, including flight instruction and flying for a commuter airline for about 5 1/2 years before being employed with Piedmont Airlines. The captain estimated his total flying time at 23,800 hours, including about 7,500 hours as pilot-in-command and about 4,500 hours on the A320. The captain's most recent proficiency check (continuing qualification training) occurred on December 19, 2013.

The captain 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. For additional information on the captain's medical condition, see the Human Performance Group Chairman's Factual Report.

A review of the FAA program tracking and reporting subsystem (PTRS) 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.

The captain was off duty March 6-12, 2014. On Monday, March 10, he woke up about 0700, had a dental appointment at 0900, then rode his bike. His activities the rest of the day were normal. He went to bed about 2200-2230. He turned on the TV, then went to sleep, and reportedly slept well.

On Tuesday, March 11, he woke up about 0630-0700. He had an appointment with his cardiologist, which was done by 1330 then he had lunch. He was not sure when he went to bed but thought it was about 2230.

On Wednesday, March 12, he was "happy and relieved" because he thought the FAA would approve him for another year to fly. He did not do much that day and went to bed early because he had to be up early the next morning. He thought he went to bed about 2100-2130 and reported no problems sleeping.

On Thursday, March 13, he woke up about 0445 and felt fine. He left his home for the airport at 0515 for the 25-minute drive to FLL and caught a 0630 flight to CLT. The 2-hour flight to CLT was uneventful, and he thought he napped about 90 minutes on the flight in an exit row seat. He arrived in CLT at 0830 and signed in for his 1035 trip about 0930. He had a cup of coffee before starting the trip. The accident crew departed CLT about 1132 and arrived at TPA at 1312. The captain ate a meal after arriving in TPA and planned to eat a crew meal during the accident flight.

The First Officer

The first officer, age 62, was hired by US Airways as a pilot on March 25, 1999; she had been hired as a flight attendant by Piedmont Airlines in July 1973. She started flying in 1986 and became a certified flight instructor for Piedmont Aviation for several years before getting hired by CCAir (a regional code-sharing partner with US Airways) in 1990. She was furloughed from CCAir for a short time before being recalled in 1991 and flew the Jetstream.

She was furloughed from US Airways from March 2, 2002, to April 15, 2007, and was trained on the A320 upon returning from furlough. The first officer estimated her total flying time at 13,000 hours, including about 4,700 hours on the A320. The first officer's most recent continuing qualification training occurred on May 15, 2013.

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 first officer, she was wearing her glasses on the accident flight, and they came off during the accident sequence. She retrieved a spare pair from her suitcase to read the Quick Reference Handbook during the evacuation.

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

The first officer was off duty March 9-12, 2014. For Monday, March 10, she did not recall when she woke up but said it was probably about 0800 because she had workers scheduled to arrive about 0900. It was a normal day and she stayed at home most of the day but may have also run some errands. She could not remember when she went to bed but it was generally around 2230-2300. She sometimes watched TV in bed. On Tuesday, March 11, and Wednesday, March 12, she awoke and went to bed about the same times as on Monday and her activities were also the same. She felt rested each morning.

On Thursday, March 13, she woke up about 0800 and left for the airport about 0930 for the 1035 report time. It was a 20- to 25-minute drive to the airport. Her natural wakeup time was around 0800. She "felt rested, felt great." She ate her lunch at the gate in TPA.

## AIRCRAFT INFORMATION

The accident airplane, an Airbus A320-214 (N113UW), serial number 1141, was manufactured in 1999. The registered owner was US Airways, Inc., and an FAA transport-category airworthiness certificate for the airplane was dated February 4, 2000. The airplane had a maximum ramp weight of 170,635 pounds and a total seating capacity of 159, which included 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 accidents or serious incidents that merited a formal investigation.

US Airways used the SABRE Flight Planning System and the Automated Takeoff Weight and Weight & Balance System. Central Load Planning calculated the final weight and balance data using the automated/manual system and applicable station information. The airplane's takeoff weight was about 152,525 pounds, including 24,090 pounds of fuel (the fuel load per the fuel slip minus the estimated fuel burn during taxi). The information also indicated that the airplane's center of gravity was within limits.

### Relevant Airplane Systems

The ECAM is a computer network that processes and displays engine and system parameters, fault monitoring, and corrective procedures on two identical center instrument panel screens. The primary components of the ECAM are two system data acquisition concentrators and two flight warning computers (FWCs).

The ECAM presents data on the engine/warning display (E/WD) on the upper ECAM display and system display (SD) on the lower ECAM display using the following 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

Displayed ECAM data include:

- Primary engine indications, fuel quantity, flap, and slat position
- Information (in the form of either a memo or advisory) and failure modes corresponding to one of three levels. A level 1 failure mode appears as an amber caution message that requires crew monitoring. A level 2 failure triggers an aural alert (a single chime), a steady MASTER CAUT light in amber, an amber caution message on the E/WD, and an automatic call of the relevant system page on the S/D. A level 2 failure means the flight crew should be aware of the failure and does not need to take immediate action but should address the issue as time permits A level 3 failure triggers a continuous aural alert, a red flashing MASTER WARN light, a red warning message on the E/WD, and an automatic call of the relevant system page on the S/D. A level 3 failure requires immediate action.
- Synoptic diagrams of aircraft systems and status messages
- Permanent flight data

In addition to the MASTER WARNING and MASTER CAUTION aural warnings, other aural warnings are: "WINDSHEAR", "PRIORITY (L/R)", "RETARD," "SPEED, SPEED, SPEED," and traffic alert and collision avoidance system and enhanced ground proximity warning system warnings. Although the altitude alert system provides an aural warning, the MASTER WARN light does not illuminate. The aural warning may still be cancelled by pressing either the MASTER WARN light or the EMER CANC push button. There are three priority levels for warnings and cautions: A level 3 warning has priority over a level 2 caution, which has priority over a level 1 caution.

On the A320, the pilot uses the thrust levers to manually select engine thrust, arm and activate autothrust, engage reverse thrust, and engage the TO/GA modes. Five detents divide each of the thrust lever sectors into four segments. As shown in figure 1, the detents are:

TO/GA: Max takeoff thrust

FLX MCT: Max continuous thrust (or FLX at takeoff)

CL: Maximum climb thrust

IDLE: Idle thrust (when the pilot moves the level out of the idle stop, reverse idle is selected)

MAX REV: Maximum reverse thrust

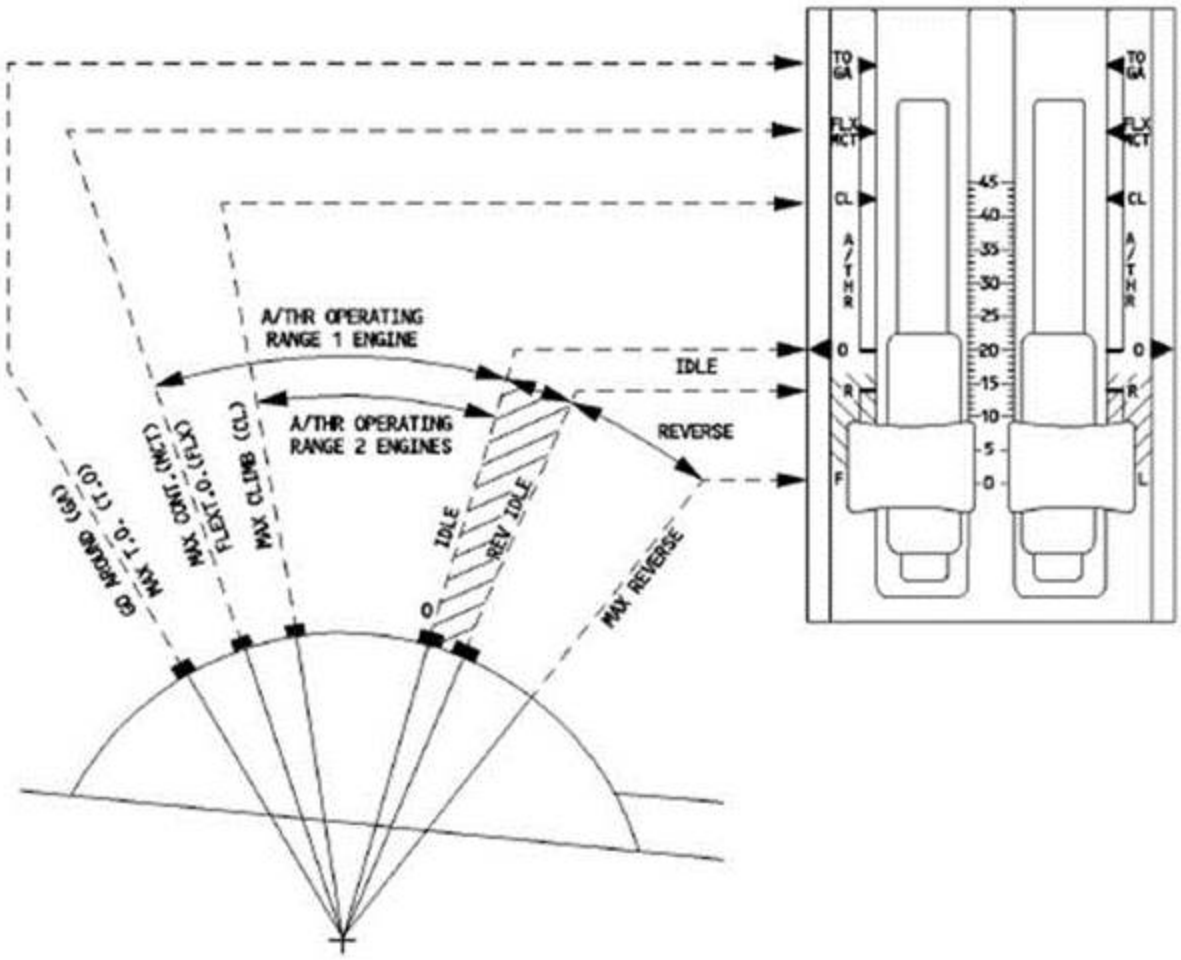


**Figure 1.** A320 Thrust Lever Positions

The TLA (thrust lever angle) is electronically measured and sent to the full authority digital engine control (FADEC) to compute the thrust rating limit. There is no mechanical connection between the thrust levers and the engines.

Each detent represents an upper thrust limit. If the thrust lever is set between two detents, the FADEC selects the rating limit for the higher detent. The thrust limit is displayed on the upper ECAM.

With the thrust lever in the FLX/MCT detent:

— On the ground: The engine would run at the FLEX takeoff thrust rating if the crew had selected a FLEX takeoff temperature on the MCDU that was higher than the current total air temperature, or TAT. Otherwise the engine would produce maximum continuous thrust (MCT). A change in FLEX TEMP during the takeoff has no effect on thrust.

— After takeoff: The pilot would move the thrust levers to TO/GA or CL then back to MCT to change FLX to MCT. The pilot may always get MAX TO thrust by pushing the thrust lever all the way forward.

The US Airways A319/320/321 Pilot Handbook, Section 2d.1.2 Setting Takeoff Thrust, states the following:

The PF [pilot flying] 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 TO/GA detent. Takeoff thrust should be set by 40 knots.

Whenever operationally feasible, US Airways "strongly recommended" pilots use FLEX thrust for takeoff to increase engine reliability and efficiency while reducing fuel consumption, engine wear, and operating costs.

US Airways A320 SOPs called for the PF to announce "FLEX" after setting FLEX thrust, and the PM to verify takeoff thrust on the E/WD and call "FLEX Set." The captain should then maintain control of the thrust levers, and the PM should verify FLEX thrust was set by verifying the flight mode annunciator (FMA) indications on top of the PFD stated "MAN FLX" with the FLEX temperature indicated.

At 80 KIAS, the PM should call "80" and PF should respond with "checked." At V1 minus 5 KIAS, the captain should remove his hand from the thrust levers, and at VR, the PF should initiate a 3 degree/second rotation up to 15 degrees. After liftoff, the PM should verify a positive rate on the vertical speed indicator (VSI), and call "positive rate," and the PF should verify the positive rate of climb and call "gear up."

The captain stated during a postaccident interview 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." According to interviews, the first officer 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."

The US Airways A319/320/321 Pilot Handbook, 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.

The US Airways A319/320/321 Pilot Handbook, Section 2d.1.2 Setting Takeoff Thrust, states the following:

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 TO/GA detent and execute a max thrust takeoff. When the thrust levers are moved to the TO/GA detent, the warning will be cancelled.

In addition, according to the US Airways 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 climb position. According to Airbus, the "ENG THR LEVERS NOT SET" ECAM message and associated chime is triggered on the A320 within 3 seconds of the thrust levers being placed above the climb detent. 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, or OAT. The US Airways A320 ECAM Supplemental Manual, page 506, also states 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 . . . . . TO/GA

According to FDR data and interviews with the accident crew, after application of takeoff thrust, the crew received a "ENG THR LEVERS NOT SET" ECAM message before 80 KIAS. CVR information shows that the first officer said "engine thrust levers not set." The captain then told the first officer "they're 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 FLEX, then reduced toward the climb detent, then returned to the FLEX position.

According the FDR data and accident crew interviews, the thrust levers were never placed in the TO/GA position on the accident flight. According to the Airbus A320 FCOM, Abnormal and Emergency Procedures – Powerplant, page 251/256, when thrust levers are set to FLEX without a FLEX temperature and the flight crew does not set the thrust levers to the TO/GA position, the FADEC will automatically select TO/GA thrust after 8 seconds. When asked why he did not push the thrust to TO/GA after he received the "ENG THR LEVERS NOT SET" ECAM message and chime, the captain reported that it was "no harm" and left the thrust in FLEX. He also said he did not reject the takeoff at that point because he had already briefed a FLEX takeoff and he did not know the speeds and assumed temperature had dropped out.

During the March 26, 2014, testing in the A320 simulator at the US Airways training facility in Charlotte, North Carolina, NTSB investigators simulated a thrust set to FLEX with no FLEX temperature entered in the FMC. A MASTER CAUTION alert triggered and the "ENG THR LEVERS NOT SET" appeared on the ECAM. In addition, the ECAM showed a message directing the pilot to place the thrust levers to TO/GA.

According to the US Airways A319/320321 TM (Training Manual), Systems Description (Takeoff Configuration Warnings/Cautions), page 10-7, if the airplane is not properly configured for takeoff, the following warnings (red) and cautions (amber) are triggered when the T.O. CONFIG push button is pressed or when takeoff power is 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 are only triggered when takeoff power is applied:

— PARK BRAKE ON

— ENG THR LEVERS NOT SET (not displayed if thrust levers are set in the TO/GA detent)

According to the US Airways A319/320/321 TM, Systems Description, when a malfunction is detected, the following occurs:

— 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.

The procedure to change runways in the FMC is defined in the US Airways A319/320/321 TM, Section 5a.4.2 Start and Before Takeoff, pages 5a-102 and -103. The procedure calls 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) are displayed on the TAKEOFF PERF page for the newly selected runway (see figure 2) and an amber scratchpad message appears in the MCDU scratchpad field that says "CHECK TAKE OFF DATA" (see figure 3). The procedure states that the previous takeoff data (V1, VR, V2, FLX TO values) will appear in small blue font beside the corresponding fields (see figure 2), and 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


**Figure 2.** Sample MCDU Takeoff page.

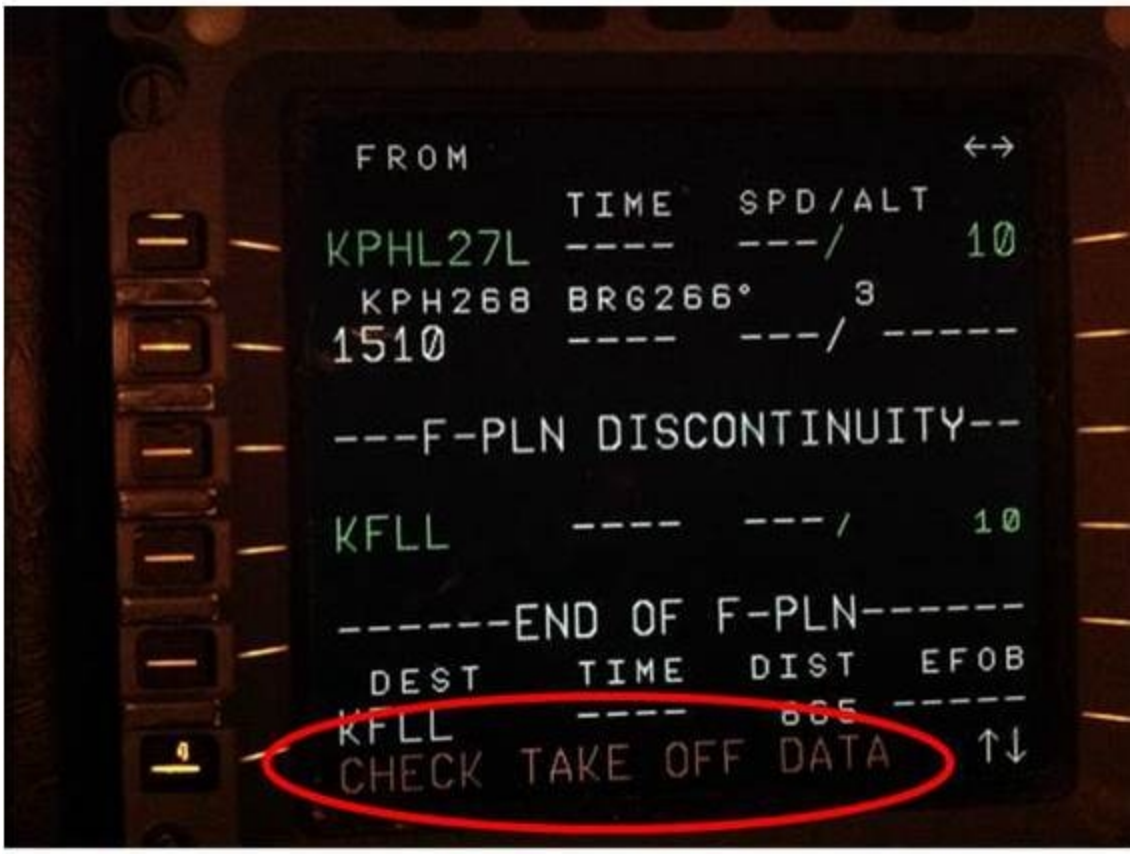


**Figure 3.** MCDU flight plan page after runway change (27R to 27L), with MCDU message (indicated).

According to the US Airways A319/320/321/ TM, Section 5a.4.2 Start and Before Takeoff, if the previous V-speeds and FLEX temperature displayed in blue font 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 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.

According to a US Airways 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. Pilots received a bulletin about the changes from FMS1 to FMS2 and were trained on the differences in subsequent continuing qualification training following the upgrade. See Attachment 1 – Interview Summaries for more information.

The first officer reported that she could not remember if they received the "CHECK TAKE OFF DATA" message, and said "we should have gotten one" since the takeoff numbers where not entered in the FMC. There was no aural alert when the "CHECK TAKE OFF DATA" message came up. She further said if

she had realized that at the point they had that message, she would have told the captain they needed a few minutes.

During the March 26, 2014, testing in an A320 simulator at the US Airways training facility in Charlotte, North Carolina, NTSB investigators 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 TO/GA target power setting since no FLEX temperature was entered (see figures 3 and 4).


**Figure 4.** Upper ECAM without FLEX temperature inserted in MCDU (TO/GA indicated).

Further, the US Airways A319/320/321 TM, Section 10.2.5 Indications on PFD, states the following concerning 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.

As shown in figure 5, a red "SPD SEL" appeared at the top of the speed tape when there were no V-speeds indicated on the PFD speed tape.


**Figure 5.** PFD after runway change with no V-speeds inserted in MCDU and SPD SEL on speed tape (indicated).

Both pilots indicated in their NTSB postaccident 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. 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 FMC.

The US Airways A320 fleet captain and several US Airways check airmen stated that A320 pilots at US Airways were regularly trained on runway changes. A review of US Airways A320 training indicated that pilots were taught MCDU runway changes in initial (qualification) training. Pilots were also taught runway changes in recurrent (continuing qualification) training during the 2009/2010 training cycle and the 2013/2014 training cycle.

The US Airways 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, NTSB investigators documented the ECAM at 80 KIAS 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 TO/GA). At 80 KIAS, the aural RETARD alert was heard. Once thrust was increased to the TO/GA detent, the alert was silenced.

According to recorded data and interviews with the accident crew, on takeoff the crew received an aural RETARD alert at a speed of about 80 KIAS after setting FLEX thrust. The captain stated that he had never heard an aural RETARD on takeoff, only knew of it on landing, and did not know what it was telling him. He further said that at 86 KIAS when they received the aural RETARD alert, he was not going to reject the takeoff because procedurally they were at high speed, they had no red warning lights, and there was nothing to suggest the need to reject the takeoff. According to Airbus, the RETARD callout is normally triggered in landing phase when the following conditions are met:

- aircraft speed is above 80 KIAS,
- AND radio-altitude is 10 ft (with autopilot engaged) or 20 ft (with autopilot disengaged)
- AND both thrust levers are not set to idle,
- AND TO/GA or FLEX MODE not engaged (GO AROUND operation).

However, according to an Airbus in-service information bulletin that was first made available to all operators in August 2008 and again in December 2013, a RETARD aural alert may be generated during a takeoff roll due to an FWC computation that did not match the flight phase. A divergence between an FWC computation and flight phase may be due to an abnormal thrust setting (that is, no engines recognized at takeoff power by the FWC). In the accident scenario, the abnormal thrust setting is due to a missing FLEX temperature and TLA remaining in the FLEX detent.

If the takeoff is initiated with an abnormal thrust setting, during the acceleration phase FWC remains in flight phase 2 and does not enter into flight phase 3 because of low TLA. When over 80 KIAS, the FWC leaves the flight phase 2 for speed above the defined threshold and computes the flight phase 8 corresponding to a landing roll (see figure 6).

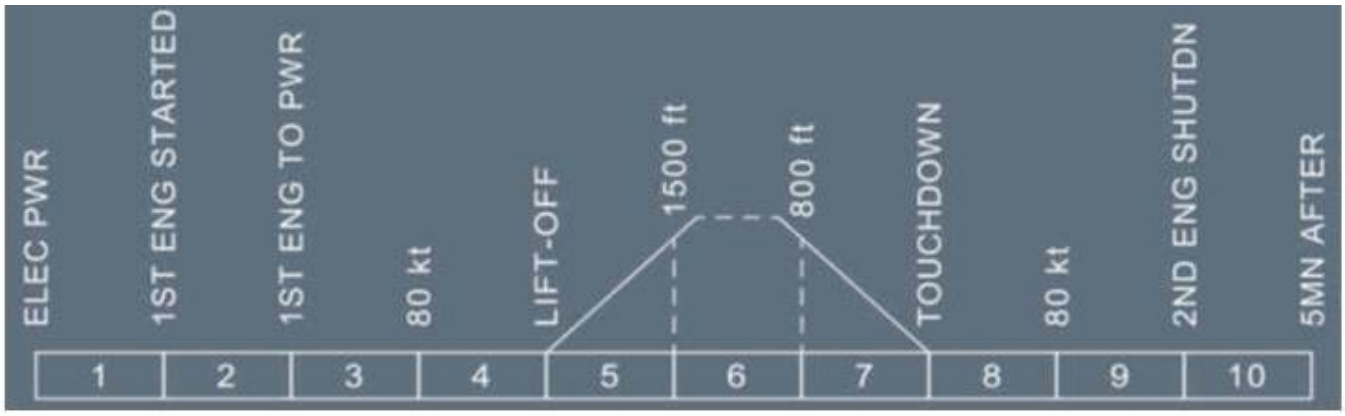


**Figure 6.** Chart of flight phase segments.

The RETARD callout is therefore triggered at around 80 KIAS. Airbus stated that, in this scenario, the RETARD callout is not associated with Master Caution or Master Warning lights, and the RETARD callout experienced during the takeoff roll is linked to a divergence between the FWC computation and the aircraft's flight phase, due to the throttles position not being set in the TO POWER condition (TO/GA or FLX/MCT TLA positions). Airbus stated that this FWC behavior is due to the TLA configuration combined with the flex temperature not being entered in the FMS.

According to Airbus, the RETARD aural alert on takeoff could be silenced by adhering to the ECAM procedure and setting the instructed thrust (TO/GA in this case). According to interviews conducted for the investigation, none of the US Airways A320 line pilots or A320 check airmen had ever heard that a RETARD alert could occur on takeoff before the flight 1702 accident. Airbus and US Airways training and manuals contain no guidance to pilots indicating how to respond to a RETARD alert on takeoff.

## METEOROLOGICAL INFORMATION

About 30 minutes before the accident, the winds at PHL were reported to be from 290 degrees true at 18 knots with gusts to 28 knots. A peak wind of 33 knots from 300 degrees true occurred at 1713, with a sea-level pressure of 1013.0 hectopascals (hPa), hourly temperature of 0.0°C and hourly dew point temperature of -20.6°C. About 30 minutes after the accident, the winds were reported to be from 300 degrees true at 12 knots with gusts to 19 knots. A peak wind of 32 knots from 290 degrees true occurred at 1805, with a sea-level pressure of 1014.7 hPa, hourly temperature of 0.0°C and hourly dew point temperature of -20.6°C. The sky condition was reported to be clear for both observations.

The automated surface observing system at PHL also recorded wind observations every minute. In the 15 minutes before the accident, the 1-minute wind average speeds ranged from 17 to 22 knots with the direction from 294 to 311 degrees, and the gusts ranged from 19 to 31 knots with the directions ranging from 281 to 322 degrees.

## FLIGHT RECORDERS

The accident airplane was equipped with a solid-state L-3/Fairchild FA2100-1020 CVR designed to record the most recent 2 hours of cockpit audio information. Specifically, it contains a 4-channel digital recording of the last 2 hours of operation. The CVR was undamaged, and data was successfully downloaded. The CVR's 2-hour, 4 minute recording contained good quality audio information on three of the channels; channel 4, recording the cockpit area microphone (CAM), was unusable. A full transcript was prepared for the accident flight and is included in the CVR Group Chairman's Factual Report.

The airplane was equipped with an Allied Signal/Honeywell Solid State FDR, which recorded flight information in a digital format using solid-state flash memory as the recording medium. The recorder was in good condition and the data were extracted normally from the recorder using the manufacturer's recommended procedures. The FDR recording contained approximately 27 hours of data.

## Wreckage AND IMPACT Information

Detailed information about the airplane impact and final resting position as well as photographs of the site were provided to the NTSB by the FAA. After contact with the runway, the airplane slid about 2,000 feet, and the final stopping point was adjacent to taxiway S10 along the edge of the runway.

Medical and Pathological Information

The accident flight crew was tested for drugs (cocaine, amphetamine, marijuana, opiates, and phencyclidine) and alcohol following the accident. The results of the screening for both flight crewmembers were negative for drugs and alcohol.

Tests and Research

Operations Group and Human Performance Group members performed several activities in a simulator to examine inputs to the MCDU and FMC, observe resulting ECAM indications, and proceed to perform similar takeoff procedures as on the accident flight and denote the resulting ECAM indications and messages generated. Observations of the Operations/Human Performance Group from the simulator sessions are denoted in the relevant subsections in Aircraft Information.

At the request of the NTSB, Airbus performed an engineering simulation of the airplane response to control inputs recorded on the FDR, using the same airplane configuration, weight and balance, trim settings, and weather information as the accident flight. The response of the engineering simulation to the control inputs was consistent with the response of the accident airplane recorded on the FDR. During the piloted simulations in both the nominal and accident configurations, the airplane was capable of flight at $V_R$.

ORGANIZATIONAL AND MANAGEMENT INFORMATION

US Airways Procedures

The US Airways A319/320/321 Pilot Handbook (PH), Section 2b.11.5 Engine Warm-Up, states:

Operate engines for at least 5 minutes before 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).

According to the US Airways A319/320/321 PH, Section 2.3.5 Checklist Format, after completing the Taxi Flows, the captain should call for and the first officer should read the first portion of the Taxi Checklist "to the line." The ? symbol in the checklist indicated "the line" and was placed in the checklist to indicate a break in the sequence. Normally, some action (that is, pushback, selecting final landing flaps, etc.) must occur before the checklist can proceed. When reading the checklist and the next item was in the line, the challenger should state "Down to the Line."

The US Airways A319/320/321 PH, Section 2.3.6 Procedures, states 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 US Airways Flight Operations Manual, Section 2.3.3 Ready for Takeoff, states:

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.

*Lack of V-Speeds on the PFD*

According to the US Airways A319/320/321 Pilot Handbook, Section 2d.6.2 "Go/No Go Concept," to compensate for reaction time, the first officer must call "$V_1$" 5 KIAS before V1, and the captain must recognize the command and respond in a timely manner. The first officer stated that she noticed there were no V-speeds depicted on the PFD at about 120-140 KIAS, and she could not call $V_1$ or $V_R$ during the takeoff. She indicated further that she made no other callouts for the takeoff. According to a US Airways A320 check airman, the "80 knot" callout was used to make sure both pilots were in the loop and also as a check for both pilots of all three airspeed indications. The first officer also said she "assumed [the captain] 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."

An A320 check airman told NTSB investigators that he had never seen anyone take off without V-speeds and that doing so was not trained; if there were no V-speeds displayed, he would expect a crew to reject the takeoff and taxi off the runway. The US Airways Airbus fleet director told NTSB investigators that, in the event a pilot did not have V-speeds displayed for reference, the airline would take that to mean the pilot did not finish the checklist and should not have taken an active runway.

The US Airways FAA aircrew program manager stated that he had never seen a situation on the line or in the simulator where a pilot initiated a takeoff roll with no visible V-speeds on the PFD. He said that the lack of V-speeds on the PFD during the initial takeoff roll would be consistent with the airline's 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 before takeoff. The US Airways managing director of flight technical operations stated that he never experienced a situation where he did not have V-speeds on takeoff and that he "wouldn't dream of taking off without V-speeds."

The captain said he had only rejected a takeoff in the simulator, usually associated with an engine fire above 80 KIAS but before $V_1$. He also stated that he had trained on rejected takeoffs above 80 KIAS and before $V_1$ but never had to execute one during line operations. When he performed the rejected takeoffs in the simulator, they "always ended up being fine."

The NTSB asked Airbus to research operator reports of departing without V-speeds on the PFD and only four reports were found. Two crews decided to perform a rejected takeoff, 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.

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

US Airways trains its captains to have their hand on the thrust levers for takeoff and remove their hand once the $V_1$ callout is made by the first officer. US Airways A319/320/321 Pilot Handbook, Section 2d.6.5 Maneuver, indicates that, when alerted to the non-normal situation before $V_1$, the captain should call "Reject, My Aircraft" while closing the thrust levers, engaging reverse thrust, and immediately applying maximum wheel braking using autobrakes or manual braking.

According to the US Airways A319/320/321 PH, Section 2d.6.4 Recommended Guidelines, and interviews with US Airways A320 check airmen, below 80 KIAS on takeoff was consider the "low speed regime," and US Airways 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 KIAS and $V_1$ 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 US Airways A319/320/321 PH, Section 2d.6.5 Maneuver, states 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 $V_1$, the decision-making process shifts in favor of the "Go" decision.

As airspeed approaches $V_1$, the stopping margin decreases 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 before $V_1$ so that the rejected takeoff maneuver can be initiated no later than $V_1$.

The captain said in his statement following the accident that he rejected the takeoff once the airplane became airborne because he "had the perception the aircraft was unsafe to fly and I decided the safest action was to not continue." He stated further that he rotated at about 159 KIAS 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. He stated that when he rotated, the main landing gear "came off the ground fine and the initial pitch felt fine."

According to interviews with US Airways Flight Training and Standards managers and A320 check airmen, rejected takeoffs before V1 were regularly trained in the simulator during initial (qualification) and recurrent (continuing qualification) training. According to US Airways check airmen, rejecting a

takeoff once airborne was not trained, and there were no US Airways procedures to cover an airborne rejected takeoff.

The Airbus Flight Operations Briefing Notes "Takeoff and Departure Operations - Revisiting the 'Stop or Go' Decision" states 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.

The captain stated during a postaccident interview that above 80 KIAS, the decision process was more toward the go decision and that 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 KIAS 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.

*Crew Resource Management*

According to the US Airways Flight Operations Training Manual chapter 18, the threat and error management (TEM) module is "intended to fully integrate technical and CRM [crew resource management] skills. Crews will follow CRM principles during line operations." The four tenets of TEM that are trained are: (1) actively monitor and assess, (2) balance available barriers, (3) communicate threats, errors and intentions, and (4) follow SOPs.

ADDITIONAL INFORMATION

Previous Events

A year before the flight 1702 accident, the flight crew of an American Airlines flight rejected a takeoff due to a similar situation; the RETARD alert sounded during takeoff and the flight crew decided to reject the takeoff. According to the Vice President of Safety, Security and Environmental for American Airlines, the company's data did not show any trends on the number of rejected takeoffs associated with the A320. The Aviation Safety Action Program group talked to the pilots and found that they did not have an assumed temperature in the FMC, and when they got the "THRUST NOT SET" ECAM message, they did not put the thrust levers to TO/GA mode.

The US Airways safety department distributed the following notice to company pilots, titled "Rejected Takeoff Events," in June 2013 informing them of the American Airlines event that 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 [first officer] changed the departure runway to 15L and manually reentered the takeoff performance data utilizing the TPS. By mistake, the Flex Temp was omitted. 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 80 kts. 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 TO/GA 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.

The US Airways Vice President of Safety did not know if there was any conversation with Airbus following the American Airlines event. He also said that the safety department conducted a study for the first 3 months of the year following the flight 1702 accident and found that the RETARD aural alert may have sounded on three other occasions. The determination was based on a look at several variables associated with the airplane's logic. The only occurrence that they knew for sure the RETARD aural alert sounded was the flight 1702 event.

On June 3, 2013, the US Airways fleet captain and director, Airbus, sent a memo to all US Airways Airbus A319/320/321 pilots titled "Flex Takeoff" that stated the following:

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 TO/GA and continue the takeoff.

Please review the procedures for Setting Takeoff Thrust as 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.

*Postaccident Actions*

On March 27, 2014, the US Airways Director of Training and Standards sent a Crew Broadcast System (CBS) message to all US Airways pilots titled "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 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:

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 TO/GA detent and execute a max thrust takeoff." If TO/GA is not selected, the RETARD aural callout is triggered when the airspeed reaches 80 knots. When the thrust levers are moved to the TO/GA 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.

On September 5, 2014, US Airways published Bulletin 21-14 as a policy change to its A319/320/321 Pilot Handbook. 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 TO/GA 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 TO/GA detent and execute a max thrust takeoff in accordance with ECAM direction. When the thrust levers are moved to the TO/GA detent, the warning

will be cancelled. (See Pilot Handbook, 2d.1.2). If the thrust levers are not moved to the TO/GA 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.

## Pilot Information

| | | | |
|---|---|---|---|
| **Certificate:** | Airline transport; Flight engineer; Flight instructor | **Age:** | 61 |
| **Airplane Rating(s):** | Single-engine land; Multi-engine land | **Seat Occupied:** | Left |
| **Other Aircraft Rating(s):** | None | **Restraint Used:** | 5-point |
| **Instrument Rating(s):** | Airplane | **Second Pilot Present:** | |
| **Instructor Rating(s):** | Airplane multi-engine; Airplane single-engine; Instrument airplane | **Toxicology Performed:** | No |
| **Medical Certification:** | Class 1 | **Last FAA Medical Exam:** | November 21, 2013 |
| **Occupational Pilot:** | Yes | **Last Flight Review or Equivalent:** | December 19, 2013 |
| **Flight Time:** | 23830 hours (Total, all aircraft), 4457 hours (Total, this make and model), 4457 hours (Pilot In Command, all aircraft), 159 hours (Last 90 days, all aircraft), 38 hours (Last 30 days, all aircraft), 6 hours (Last 24 hours, all aircraft) | | |

## Co-pilot Information

| | | | |
|---|---|---|---|
| **Certificate:** | Airline transport; Flight instructor | **Age:** | 62 |
| **Airplane Rating(s):** | Single-engine land; Multi-engine land | **Seat Occupied:** | Right |
| **Other Aircraft Rating(s):** | None | **Restraint Used:** | 5-point |
| **Instrument Rating(s):** | Airplane | **Second Pilot Present:** | |
| **Instructor Rating(s):** | Airplane single-engine; Instrument airplane | **Toxicology Performed:** | No |
| **Medical Certification:** | Class 1 With waivers/limitations | **Last FAA Medical Exam:** | December 5, 2013 |
| **Occupational Pilot:** | Yes | **Last Flight Review or Equivalent:** | May 15, 2013 |
| **Flight Time:** | 6713 hours (Total, all aircraft), 4784 hours (Total, this make and model), 163 hours (Last 90 days, all aircraft), 47 hours (Last 30 days, all aircraft), 6 hours (Last 24 hours, all aircraft) | | |

## Aircraft and Owner/Operator Information

| | | | |
|---|---|---|---|
| **Aircraft Make:** | Airbus | **Registration:** | N113UW |
| **Model/Series:** | A320 - 214 214 | **Aircraft Category:** | Airplane |
| **Year of Manufacture:** | 1999 | **Amateur Built:** | |
| **Airworthiness Certificate:** | Transport | **Serial Number:** | 1141 |
| **Landing Gear Type:** | Retractable - Tricycle | **Seats:** | 159 |
| **Date/Type of Last Inspection:** | March 13, 2014 Continuous airworthiness | **Certified Max Gross Wt.:** | 169754 lbs |
| **Time Since Last Inspection:** | | **Engines:** | 2 Turbo fan |
| **Airframe Total Time:** | 44230 Hrs at time of accident | **Engine Manufacturer:** | CFM INTL |
| **ELT:** | | **Engine Model/Series:** | CFM56 Series |
| **Registered Owner:** | US AIRWAYS INC | **Rated Power:** | 27000 |
| **Operator:** | US AIRWAYS INC | **Operating Certificate(s) Held:** | Flag carrier (121) |

## Meteorological Information and Flight Plan

| | | | |
|---|---|---|---|
| **Conditions at Accident Site:** | Visual (VMC) | **Condition of Light:** | Day |
| **Observation Facility, Elevation:** | KPHL | **Distance from Accident Site:** | 0 Nautical Miles |
| **Observation Time:** | 21:54 Local | **Direction from Accident Site:** | |
| **Lowest Cloud Condition:** | Clear | **Visibility** | 10 miles |
| **Lowest Ceiling:** | None | **Visibility (RVR):** | |
| **Wind Speed/Gusts:** | 18 knots / 28 knots | **Turbulence Type Forecast/Actual:** | / |
| **Wind Direction:** | 302° | **Turbulence Severity Forecast/Actual:** | / |
| **Altimeter Setting:** | 29.92 inches Hg | **Temperature/Dew Point:** | 0°C / -21°C |
| **Precipitation and Obscuration:** | | | |
| **Departure Point:** | Philadelphia, PA (KPHL) | **Type of Flight Plan Filed:** | IFR |
| **Destination:** | Fort Lauderdale, FL (KFLL) | **Type of Clearance:** | IFR |
| **Departure Time:** | | **Type of Airspace:** | Class B |

## Airport Information

| | | | |
|---|---|---|---|
| **Airport:** | Philadelphia International KPHL | **Runway Surface Type:** | Asphalt |
| **Airport Elevation:** | 36 ft msl | **Runway Surface Condition:** | Dry |
| **Runway Used:** | 27L | **IFR Approach:** | None |
| **Runway Length/Width:** | 10506 ft / 200 ft | **VFR Approach/Landing:** | None |

## Wreckage and Impact Information

| | | | |
|---|---|---|---|
| **Crew Injuries:** | 5 None | **Aircraft Damage:** | Substantial |
| **Passenger Injuries:** | 149 None | **Aircraft Fire:** | None |
| **Ground Injuries:** | N/A | **Aircraft Explosion:** | None |
| **Total Injuries:** | 154 None | **Latitude, Longitude:** | 39.860553,-75.273887(est) |

## Administrative Information

| | |
|---|---|
| **Investigator In Charge (IIC):** | Bower, Daniel |
| **Additional Participating Persons:** | |
| **Original Publish Date:** | February 24, 2016 |
| **Last Revision Date:** | |
| **Investigation Class:** | Class 2 |
| **Note:** | The NTSB traveled to the scene of this accident. |
| **Investigation Docket:** | https://data.ntsb.gov/Docket?ProjectID=88921 |