

7 February 2020
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Bill English
Investigator In Charge
National Transportation Safety Board
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Subject: Boeing Submission for Atlas Air 767-300BCF N1217A Accident near
Houston, Texas, 23 Feb 2019

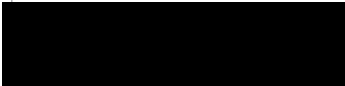
References: E-mail, 17 January 2020, NTSB to Boeing, Re: Atlas DCA19MA086 Tech
Review

Dear Mr. English:

As requested in the reference e-mail regarding the technical review, please find the attached Boeing submission on the subject accident. Per your request we are sending this electronic version to your attention for distribution within the NTSB.

We would like to thank the NTSB for giving us the opportunity to make this submission. If you have any questions, please don't hesitate to contact us.

Best regards,


Robert J. McIntosh
Director, Product Safety

Enclosure: Boeing Submission to the NTSB for the subject accident



Submission to the
National Transportation Safety Board
for the

**Atlas Air 767-300BCF N1217A
Flight 3591 Accident
Trinity Bay, TX
23 February 2019**

**The Boeing Company
07 February 2020**



INTRODUCTION

On February 23, 2019, at 1239 central standard time (CST), Atlas Air flight 3591, a Boeing 767-300BCF, registration number N1217A, entered a rapid descent from 6,000 ft and impacted a marshy bay area about 34 miles southeast of George Bush Intercontinental Airport (IAH), Houston, Texas. The airplane was destroyed upon impact. The two pilots and one non-revenue jumpseat pilot were fatally injured. The airplane was operated as a Title 14 Code of Federal Regulations (CFR) Part 121 domestic cargo flight, which originated from Miami International Airport (MIA), Miami, Florida, and was destined for IAH.

Submission Abstract

- The Boeing Company, as the airplane's manufacturer, is an invited party to the investigation and provides technical and operational assistance to the National Transportation Safety Board (NTSB) in its investigation.
- The conclusions presented in this submission are based on factual information received from the NTSB, Boeing expertise, the use of analytical tools, and a methodical investigation process.
- While being vectored around weather and descending through 6,300 feet, the airplane autoflight and autothrottle systems entered go around mode. This simultaneous mode engagement can only occur when the go around autothrottle mode is armed and either go around switch on the thrust lever assembly is actuated. It is possible that inadvertent activation of a thrust lever assembly go around switch occurred.
- Review of data from the Flight Data (FDR) and Cockpit Voice Recorder (CVR) shows that the airplane and all airplane systems were functioning as designed when go around mode was engaged and during the subsequent rapid descent.
- Review of FDR data and airplane performance characteristics show that the airplane did not enter a stall at any time during the accident flight.
- Examination of recovered airplane wreckage and systems components showed no evidence of a cargo load shift or any other airplane structural or system anomalies.
- Spatial disorientation may have been experienced by the first officer.

BOEING ASSISTANCE WITH THIS INVESTIGATION

The National Transportation Safety Board (NTSB) is conducting the investigation into this Atlas Air 767-300BCF accident. Assisting the NTSB in their investigation are the Federal Aviation Administration (FAA); General Electric Aviation; Boeing; Atlas Air; International Brotherhood of Teamsters; and other designated parties.

As the manufacturer of the 767-300BCF airplane, Boeing's specific role in this investigation has been to provide technical information regarding the airplane design, manufacture, and operation to assist the NTSB.



The NTSB requested that all parties submit proposed findings to be drawn from the factual information established during the course of the investigation. Boeing responds to the NTSB request with this document, which:

- Provides an assessment of the factual information and other pertinent data;
- Identifies knowledge gained from the investigation; and
- Identifies conclusions supported by the knowledge gained from the investigation.

BOEING ASSESSMENT

The Boeing assessment of the accident is based upon the facts as documented in the NTSB's factual reports, Boeing expertise, the use of analytical tools, and a methodical investigation process. These reports contain observations of the airplane wreckage and accident site, post-accident examination of airplane systems and components, flight data recorder (FDR) data, the cockpit voice recorder (CVR) transcript, airline maintenance records, flight crew training records, and interview data.

WEATHER

The accident site location was at 29.76416667° north latitude, 94.71383333° west longitude near Anahuac, Texas in Trinity Bay. Around the time of the accident a cold front was present stretching from Arkansas through far southern Texas advancing to the southeast and extending almost directly over the accident site.¹ Surface winds ahead of the front were generally southerly to southwesterly and cloudy conditions existed along and ahead of the front near the accident location. Surface observations from weather stations (KHOU, KIAH, KBMT, and KBPT) surrounding the accident site indicated that a broken cloud ceiling of between 2,000 feet 2,500 feet agl (above ground level) existed at times adjacent to when the accident occurred.² Near the time of the accident, weather radar imagery from Houston, Texas (KHGX) indicates that a fine line outflow feature was present over Trinity Bay between convective activity west of the Houston Metro area and the accident airplane flight path.³ Video of the Trinity Bay area near the time of the accident shows the presence of a shelf cloud that is likely associated with this fine line.

Surface winds in the accident area prior to the accident were from the south-southwest at about 15 knots increasing to about 45 knots at about 15,000 feet. The potential for light clear air turbulence below 15,000 feet and moderate clear air turbulence between about 2,800 and 4,500 feet was present. After the accident, surface winds in the area were from the west at about 10 knots increasing to below 20 knots through about 3,600 feet. The potential for light clear air turbulence above 3,600 feet and moderate clear air turbulence between about 4,500 and 5,600 feet existed.⁴ Pilot reports in the area during times prior to and after the accident below 15,000

¹ NTSB Meteorology Factual Report, dated 26 September 2019, page 4

² NTSB Meteorology Factual Report, dated 26 September 2019, pages 5 - 8

³ NTSB Meteorology Factual Report, dated 26 September 2019, pages 9 - 15

⁴ NTSB Meteorology Factual Report, dated 26 September 2019, page 16



feet indicate moderate turbulence was experienced with descriptions of light and moderate chop.

THE ACCIDENT AIRCRAFT

The Boeing Company delivered the airplane (registration N1217A, serial number 25865) on July 16, 1992 to another airline customer. The airplane had 91,047 total hours with 23,313 total cycles at the time of the accident. The airplane was equipped with two CF6-80C2-B6F engines. The airplane was equipped with APB (Aviation Partners Boeing) winglets installed in 2010. The airplane was modified from a 767-300ER passenger configuration to a Boeing converted freighter (767-300BCF) configuration in 2017.

SEQUENCE OF EVENTS

Below is a chronological overview of the events that occurred based on the FDR data, the CVR transcript, weather data, and ATC transcripts. The events below are referenced to local time (hh:mm:ss) which was Central Standard Time (CST). All times should be considered approximate.

Local Time (CST)	Event Description
12:24:54	The airplane begins its descent into the Houston area from an altitude of approximately 34,000 feet with FO as PF ⁵ .
12:30:38	The flight crew contacts Houston Approach descending through 17,800 feet and received instructions from the arrival controller to fly the KIAH runway 26L transition of the LINKK ONE RNAV ARRIVAL.
12:34:09	ATC informs the flight crew of light to heavy precipitation to the west and the possibility of receiving vectors around the weather.
12:35:47	The flight crew contacts the ATC approach controller while descending through 11,400 feet and the controller indicates that vectors would be required for runway 26L and asked how they wanted to get around the weather.
12:36:07	The FO mentions a phonetic “F” sound attributed by the NTSB as a concern with a display.
12:36:10	Control is transitioned and the CA becomes PF.

⁵ Abbreviations: Captain (CA), First Officer (FO), Pilot Flying (PF), Pilot Monitoring (PM)

Local Time (CST)	Event Description
12:36:21	The FO informs ATC that they will fly west of the weather.
12:36:45	ATC informs the crew to “hustle down” and maintain 3,000 feet to get the flight west of the weather and northbound for a base leg to the runway.
12:36:55	The MCP ⁶ selected altitude is set to 3,000 feet.
12:37:03	The speedbrake handle is manually moved to the UP position.
12:37:07	FO mentions EFI ⁷ button and states “I got it back” less than two seconds later.
12:37:16	ATC instructs the flight crew to turn left to a heading of 270 and the airplane begins a left turn about 10 seconds later.
12:37:25	Control is transitioned back and the FO becomes PF.
12:37:27	The flight crew discusses FMC inputs for the approach for about the next 24 seconds.
12:38:05	The CA moves the flap handle to the “1” position.
12:38:26	Increasing perturbations in computed airspeed, angle of attack, accelerations, and control inputs begin to occur consistent with the aircraft entering turbulence as the airplane passes 6,500 feet.
12:38:31	The sound of a click is heard on the CVR and a transition to the autothrottle go around mode is recorded shortly afterwards on the FDR and the thrust levers begin to move forward. The airplane was at an altitude of about 6,300 feet.
12:38:37	The speedbrake handle is manually retracted to the ARMED position and the engines reach go around power settings.
12:38:40	The control column is recorded on the FDR as being deflected forward at this time. A sound consistent with the Beeper aural

⁶ Mode Control Panel (MCP)

⁷ Electronic Flight Instruments (EFI).

Local Time (CST)	Event Description
	caution warning occurs on the CVR and the Master Caution and Autopilot Caution discrete parameters are recorded as active on the FDR.
12:38:44	The FO made an expression of surprise and comments about speed.
12:38:46	The thrust levers are brought to idle for 2 seconds and then re-advanced. (The rate of movement is consistent with manual input as the rate exceeds the maximum autothrottle rate command). Pitch attitude was rapidly decreasing near this time and recorded vertical g became negative for nearly 11 seconds.
12:38:47	The CA responds to ATC and a split between the left and right elevator positions begins and lasts for about 10 seconds.
12:38:48	The FO makes comments about stalling.
12:38:55	The Master Warning and Overspeed discrete parameters are recorded as active near this time as airspeed exceeds the maximum operating speed (V _{MO}) of 360 knots. A sound consistent with the aural Siren warning alert is recorded on the CVR within 1 second. The CA asks “what’s going on?”
12:38:58	The elevator positions become symmetric, the airplane transitions out of go around mode near the selected altitude of 3,000 feet, and full airplane nose up control column is commanded as the airplane descends through 2,000 feet.
12:39:03	End of recordings.

AIRPLANE STRUCTURES

A wreckage layout was performed in a warehouse in Baytown, TX by the NTSB structures and systems groups which included representatives from Boeing and other party members. Identifiable wreckage was arranged in a two-dimensional reconstruction grid on the warehouse floor. Digital maps of the major sections of the airplane were created under the direction of the NTSB.⁸ Wreckage was identified and documented from the fuselage, wing upper and lower surfaces, horizontal stabilizer upper and lower surfaces, vertical stabilizer and rudder, engines, systems components, center wing structure, cargo handling components, rigid cargo barrier, and flight deck components. There was no evidence of fire and all fracture surfaces

⁸ NTSB Structures Group Chairman’s Factual Report, dated 29 October 2019, page 4



examined were consistent with overstress separation. There was no evidence of a cargo load shift or any other airplane structural anomalies.

AIRPLANE SYSTEMS

The recovered systems components were segregated in the warehouse and were examined and cataloged by the NTSB systems group which included representatives from Boeing. Over 360 recovered system components were catalogued and several flight control system components were subjected to a more detailed review and further examination under direction of the NTSB. These components were the elevator power control actuators (PCAs), center autopilot elevator servo, and the thrust lever assembly. The NTSB also requested that the manufacturer of the symbol generators (Collins Aerospace) perform an evaluation of the Electronic Flight Instruments (EFI) source select switch function to document the symbol generator selection timing during certain failure scenarios. The results of the examinations and evaluations conducted showed no evidence of a pre-impact system component failure⁹ or anomaly. The available evidence indicates that all airplane systems were functioning as designed prior to the accident.

Laboratory Examination and Evaluation

The recovered elevators PCAs were further examined at the manufacturer (Parker Aerospace) under direction of the NTSB. The PCAs and related components were disassembled and documented including linkages, cylinders, and control valve slides and sleeves. One mostly intact control valve free of corrosion was able to be functionally tested and subsequently passed all acceptance tests. The remainder were deemed to have experienced impact damage or corrosion which precluded testing. The examination group determined that there was no evidence of an elevator PCA failure.¹⁰

The center autopilot elevator servo was further examined at the manufacturer (Moog) under the direction of the NTSB. The unit was disassembled and documented including the electrohydraulic servovalve (EHSV). No evidence of a pre-impact system failure was noted.

The thrust lever assembly was further examined at the Boeing Equipment Analysis laboratory in Seattle, WA under direction of the NTSB. This examination included the two go around switches installed in the assembly. Each go around switch contains three micro-switches. Each micro-switch was actuated and switch function and wiring continuity was confirmed. No evidence of any pre-impact failure or damage was noted for either of the two go-around switches or wiring internal to the thrust lever assembly.¹¹

An evaluation of the EFI source select switch timing and display interaction was performed by the symbol generator manufacturer (Collins Aerospace) on a test article. Selection of the EFI switch results in power being applied to an alternate symbol generator source for the electronic

⁹ NTSB Systems Group Chairman's Factual Report, dated 16 December 2019, page 4

¹⁰ NTSB Systems Group Chairman's Factual Report, dated 16 December 2019, page 16

¹¹ NTSB Systems Group Chairman's Factual Report, dated 16 December 2019, page 34



attitude display instrument (EADI) and electronic horizontal situation indicator (EHSI). The evaluation shows that when the EFI switch is selected to ALTN the affected EADI and EHSI will blank and return within 2 seconds.¹² Likewise, selection of the EFI switch from ALTN to a normal setting will result in power up of the primary symbol generator with the blank and return of the EADI and EHSI within 2 seconds. This shows that a primary symbol generator can be reset with selection of the EFI switch to ALTN and back to normal within 4 seconds.

OPERATIONAL FACTORS / HUMAN PERFORMANCE

The flight crew consisted of the Captain (CA) and First Officer (FO). The FO was the pilot flying (PF) at the time of the accident and the CA was the pilot monitoring (PM). A non-revenue pilot was seated in a flight deck jumpseat during the accident.

History of Flight – Approach into Houston

The airplane was descending on the LINNK ONE RNAV arrival into KIAH when the ATC controller advised the crew of light to heavy precipitation about 35 miles ahead of the flight. ATC informed the crew to expect vectors around the weather. When ATC asked for the flight crew's preference for vectors to runway 26L the crew chose to fly to the west of the weather. ATC then instructed the flight crew to expedite their descent to 3,000 feet to avoid outbound departure traffic and turn left to a heading of 270. The crew acknowledged the descent, entered 3,000 feet as the selected altitude in the MCP, extended the speedbrakes to increase the descent rate, and selected a heading of 270 on the MCP. The 767 Atlas-Polar FCOM indicates that the PF should keep a hand on the speedbrake lever when the speedbrakes are used in-flight to prevent leaving the speedbrake extended when no longer required. The flight crew then prepared the airplane for approach and landing by entering information into the FMC and extended the flaps to the 1 detent. When the flap position is out of UP, the go around autothrottle mode becomes armed. The center autopilot and autothrottle were already engaged at this time and remained engaged throughout the rest of the flight. There is no evidence that any attempt was made to disconnect the autopilot or autothrottle.

About 22 seconds after the flaps were positioned at 1, fluctuations in tri-axial accelerations were recorded on the FDR consistent with light to moderate turbulence.¹³ About 5 seconds after these fluctuations, the go around autothrottle and autopilot modes were engaged. This mode engagement can only occur when the go around autothrottle mode is armed and one or both of the two go around switches on the thrust lever assembly are actuated. These modes are annunciated on the 767 as shown in Figure 1 on the Flight Mode Annunciation (FMA) portion of both the CA and FO EADI displays. The 767 FCOM go around procedure indicates that the PF call for "GO-AROUND, FLAPS 20" after pushing the go around switch. The 767 FCOM also indicates that AFDS mode annunciations are expected to be monitored by both pilots which are displayed on their respective FMA. No verbal call for go around or comments regarding mode annunciation changes on the FMA were audible on the CVR.

Following go around engagement, there was an increase in engine thrust and aft deflection of the control column as commanded by the autothrottle and center autopilot while in go around

¹² NTSB Systems Group Chairman's Factual Report, dated 16 December 2019, page 46

¹³ NTSB FDR Specialist's Factual Report, dated 13 December 2019, page 5

mode. The airplane began to climb at this time. About 6 seconds after the commanded increase in thrust the speedbrakes were manually retracted and the engines reached the commanded go around thrust. About 3 seconds later, the control column was deflected forward for 10 seconds in opposition to the autopilot commands resulting in annunciation of the AUTOPILOT Caution EICAS message (aural beeper, autopilot light, master caution light, and message on EICAS status display). This is expected when a single channel autopilot is overridden by motion of the control column. The CA continued normal ATC communications at this time and there was no discussion regarding a command or callout for go around, AFDS mode annunciation change, stowing of speedbrakes, or acknowledgment of the AUTOPILOT Caution noted on the CVR recording.

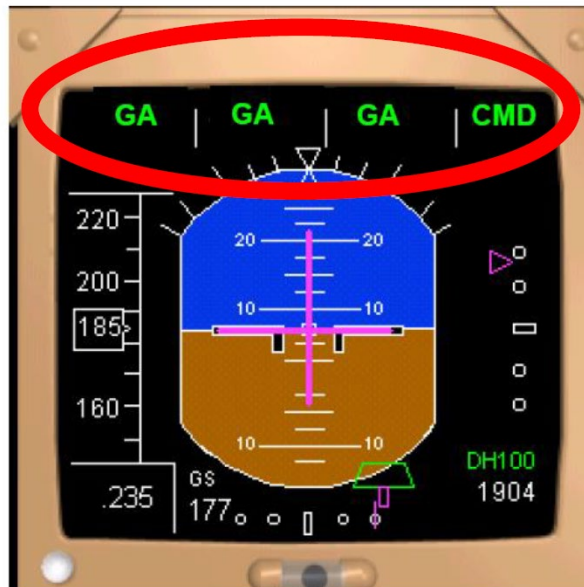


Figure 1 – Go Around AFDS mode annunciations on the EADI FMA¹⁴

The FO made an expression of surprise. After the airplane descended through 6,000 feet, the FO made comments regarding airspeed and stalling several seconds later. No stall warning indications were recorded on the CVR or FDR, and recorded parameters indicate flight well below the wing stall angle-of-attack.¹⁵ The CA responded to ATC around this timeframe. Shortly afterwards, the FDR recorded a split in left and right elevator position at this time for 10 seconds indicating potential opposing control column inputs. As the airplane descended through the MCP selected altitude of 3,000 feet the AFDS and autothrottle transitioned out of go around mode and thrust lever position began to decrease. As the airplane descended through 2,000 feet the elevator split subsided and the control column was moved to the aft stop with both elevators in the trailing edge up position (airplane nose up) for the remainder of the flight. Weather data suggests the cloud ceiling at the airplane's location at this time was likely broken between 2,000 to 2,500 feet agl which indicates the transition to nose up elevator likely occurred as the airplane entered visual conditions near this altitude.

¹⁴ NTSB Operational Factors/Human Performance Factual Report, dated 19 November 2019, page 67

¹⁵ NTSB Airplane Performance Study Specialist Report, page 3

Spatial Disorientation

Spatial disorientation can occur when a pilot cannot distinguish between a change in airplane longitudinal acceleration and a change in pitch attitude. A natural reaction is to lower the nose of the airplane in response to increased acceleration and misleading pitch attitude perception. The data presented in the NTSB Airplane Performance Study suggests that spatial disorientation may have occurred during the accident sequence. Initial manual forward control column deflections and split elevator positions after increased longitudinal acceleration during go around engagement and subsequent manual aft control column deflections and symmetric elevator positions when entering visual conditions supports this. Upset recovery guidance in the 767 FCTM provides guidance to recognize and confirm an upset and recommends assessment of airplane attitude, airspeed, altitude, and trend information through instrument crosscheck. The 767 FCOM QRH provides nose low upset recovery guidance with initial actions to disconnect the autopilot and autothrottle along with call outs for attitude, airspeed, and altitude throughout the recovery. As no autopilot or autothrottle disconnect occurred and no instrument call outs or crosscheck are audible on the CVR during this event, the flight crew was likely disoriented until symmetric nose up elevator was applied.

Pilot Hand Position

Simulator sessions conducted by the NTSB in Miami documented several FO hand positions on the speedbrake lever in relation to the go around switches on the thrust levers. These sessions showed that there are speedbrake lever hand positions in which contact with the go around switches is possible.

KNOWLEDGE GAINED DURING THE INVESTIGATION (Findings)

The following knowledge gained is pertinent to drawing conclusions:

- Weather conditions such as light to moderate turbulence were likely experienced just prior to go around mode activation.
- While being vectored around weather and descending through 6,300 feet, the autoflight and autothrottle systems entered go around mode. This simultaneous mode engagement can only occur when the go around autothrottle mode is armed and either go around switch on the thrust lever assembly is actuated. It is possible that inadvertent activation of a thrust lever assembly go around switch occurred.
- The flight crew did not appear to be aware of go around mode activation as the go around was not verbally called out and none of the FMA changes during go around mode transition or the subsequent descent were noted.
- Review of data from the Flight Data (FDR) and Cockpit Voice Recorder (CVR) shows that the airplane and all airplane systems were functioning as designed when go around mode was engaged and during the subsequent rapid descent.
- Review of FDR data and airplane performance characteristics show that the airplane did not enter a stall at any time during the accident flight.
- Examination of recovered airplane wreckage and systems components showed no evidence of a cargo load shift, system malfunction, or any other airplane structural or system anomalies.



- Spatial disorientation may have been experienced by the first officer potentially contributing to manual airplane nose down control column inputs.

CONCLUSIONS

Boeing believes that the evidence supports the following conclusions for the accident:

This accident occurred due to manual airplane nose down control column inputs that occurred after activation of go around mode during the descent phase of flight at an altitude near 6,300 feet. Activation of the go around mode was potentially due to inadvertent actuation of a thrust lever assembly go around switch as the flight crew appeared to be unaware of this mode change. Manual control column inputs may have been the result of flight crew reaction to spatial disorientation.