BOEING®

Submission to the

National Transportation Safety Board

for the

FedEx 727-200 Flight 1478

Accident Investigation

The Boeing Company

14 March 2003

INTRODUCTION

On July 26, 2002, at 0540 eastern daylight time, a FedEx 727-200, N497FE, crashed while attempting a night visual approach to Tallahassee Regional Airport, Florida. The airplane was operating as Flight 1478 on a cargo flight from Memphis, Tennessee, to Tallahassee. Pre-dawn lighting conditions (darkness) existed at the time of the accident and the weather was clear with calm winds. The airplane was destroyed by impact and post-crash fire. The accident did not result in any fatalities.

Submission Abstract

- The Boeing Company, as the airplane's manufacturer, is acting as a technical and operational advisor to the National Transportation Safety Board (NTSB) in this investigation.
- The conclusions presented in this submission are based on factual information, Boeing expertise, the use of analytical tools, and a methodical investigation process.
- The airplane and airplane systems were functioning normally during the landing sequence.
- Runway 27 at Tallahassee Regional Airport is ILS equipped, while Runway 9 is not ILS equipped and has at least two features (upslope and "black hole" effect) that are common factors in CFIT accidents during night visual approaches.
- This was a Controlled Flight Into Terrain (CFIT) accident in which the flight crew did not recognize that the airplane was flying considerably below the expected approach path. Possible contributors to this low approach were the visual perceptions associated with an upsloped runway and the black hole effect. In addition, the cursory supplementary briefing for runway 9 represented a CFIT awareness opportunity lost.
- When available, the use of instrument landing aids should be encouraged for all approaches at night or in low visibility conditions, especially at airports identified as a CFIT risk. This is not intended to be an airplane restriction but rather a prudent operational risk reduction measure.
- Boeing has a longstanding history of a proactive role within industry in educating flight crews about CFIT. Boeing remains committed to continuing to actively participate with industry to work toward eliminating CFIT accidents altogether.

BOEING ASSISTANCE WITH THIS INVESTIGATION

The National Transportation Safety Board (NTSB) led the investigation into this FedEx 727 accident. Assisting the NTSB in their investigation were the Federal Aviation Administration (FAA), FedEx, the Airline Pilots Association (ALPA), the National Air Traffic Controllers Association (NATCA), the Tallahassee Regional Airport, Boeing, and other designated parties.

As the manufacturer of the 727-200 airplane, Boeing's specific role in this investigation has been to provide technical information regarding the airplane design and operation to assist the NTSB.

Furthermore, the NTSB requested that all parties submit proposed findings to be drawn from the evidence revealed during the course of the investigation. Boeing has responded to the NTSB request with this document, which:

- Provides an assessment of the evidence and other pertinent data.
- Identifies knowledge gained from the investigation.
- Identifies a conclusion and recommendation supported by the knowledge gained from the investigation.
- Describes the actions taken by Boeing to enhance the safety of the in-service fleet.

EVIDENCE ASSESSMENT

The Boeing assessment of the evidence is based upon observations of the wreckage and accident site, post-accident examination of airplane systems components, flight data recorder (FDR) data, radar data, the cockpit voice recorder (CVR) transcript, and flight crew interview data.

TALLAHASSEE REGIONAL AIRPORT

The control tower at Tallahassee Regional Airport (TLH) was operational between the hours of 6:00 am and 11:00 pm, daily. When the TLH tower was not in operation, air traffic management was provided by Jacksonville Air Route Traffic Control Center[1]. Since the accident occurred at 5:37 am, the TLH tower was not in operation at the time of this accident.

TLH runway 9 is equipped with a Precision Approach Path Indicator (PAPI) visual landing system and is not Instrument Landing System (ILS) equipped. After the accident, the PAPI calibration was checked and confirmed to be within requirements by the FAA[1]. Note that runway 27 was equipped with an ILS that was operational at the time of the accident[2].

The TLH runway lighting system operates in two different modes depending on whether the tower is open or not. When the tower is open, the lighting system is controlled from the tower cab. When the tower is closed, Pilot-Controlled Lighting (PCL) mode is utilized, allowing the lights to be activated via radio clicks. The pilot controlled lighting at TLH was configured so that the runway edge lights, taxiway lights and the PAPI were off until activated by a series of microphone clicks from the approaching aircraft. At the time of the accident, the lights were in PCL mode[1].

The middle of runway 9/27 is higher in elevation than the threshold at either end. This results in the initial part of runway 9 sloping uphill from the threshold. An upsloped runway such as this, may give the crew of an approaching airplane the visual perception of being too high. To correct this perception, crews may descend lower than intended. This effect is intensified at night when the runway lights are visible, but the topography of the surrounding terrain is not. Additionally, the approach to runway 9 is over an area of undeveloped National Forest that is without house or street lights as visual cues at night. This is typically referred to as a "black hole"[3]. Both runway upslope and black hole effect are common factors that may contribute to CFIT during a night visual approach.

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[1] NTSB Air Traffic Control Group Chairman's Factual Report, dated 24 Sep 02

[2] NTSB Survival Factors Group Chairman's Factual Report, dated 27 Nov 02

[3] Boeing Airliner Magazine Article, "Black Hole Approaches", Jan-Mar 1994 issue

AIRPLANE PERFORMANCE

Examination of the FDR data revealed that the airplane was responding normally to crew inputs prior to impact with the trees. All airplane systems were found to be functioning properly, including the flight controls and high lift systems. The leading edge slats and the trailing edge flaps were all in the commanded positions prior to impact with the trees[4]. No mention of airplane problems was made during interviews with the flight crew[5]. Thus, there is no evidence that suggests the airplane or airplane systems contributed to the accident.

At the beginning of the accident sequence, shortly after the initial impact with the trees, the airplane rolled to the right until the right wingtip contacted the ground. The roll to the right could not be arrested, even though full left control wheel and full left pedal were applied by the crew[6]. This roll to the right is consistent with a trailing edge flap asymmetry caused by separation of the right outboard trailing edge flap segments from the airplane. Examination of the crash site confirmed that the right outboard trailing edge flap segments were among the first parts found in the debris field, and were downstream of the first tree impact[7]. Additionally, several trips made upstream of the debris field, both on foot and by helicopter, verified that no parts had departed the airplane prior to the first tree impact. Therefore, the roll to the right occurred as a result of impact with the trees, and not vice versa.

A Ground Proximity Warning System (GPWS) was installed and operational on the accident airplane. The expected GPWS mechanical altitude callouts are shown on the CVR transcript during final approach[8]. The installed GPWS correctly issued a Mode 6 bank angle alert[9] during the roll to the right (discussed above), but did not issue any warnings prior to impact with the trees. Analysis of the FedEx 727 flight profile verified that none of the installed GPWS warning thresholds would have been penetrated[9]. Thus, it was confirmed that the installed GPWS was not expected to issue any other alarms. FedEx stated that the airplane was scheduled to receive an upgrade to an Enhanced Ground Proximity Warning System (EGPWS) three days after the accident date. Examination of the flight path of the accident flight indicates that an EGPWS also would not have generated an alarm[9].

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[4] NTSB Systems Group Chairman's Factual Report, dated 4 Oct 02

[5] NTSB Operations Group Chairman's Factual Report, dated 10 Dec 02

[6] NTSB Performance Study, dated 6 Nov 02

[7] NTSB Structures Group Chairman's Factual Report, dated 12 Sep 02

[8] NSTB Cockpit Voice Recorder Group Chairman's Factual Report, dated 12 Nov 02

[9] Addendum to NTSB Systems Group Chairman's Factual Report, dated 19 Feb 03

CVR TRANSCRIPT

The following observations are made from the CVR transcript[8] and from FDR data. The times used with each CVR statement below are shown as –mm:ss indicating minutes:seconds prior to impact with the first tree. Immediately following the CVR statement(s) is a discussion of the significance of the statement(s). For reference, the First Officer was the pilot flying.

Decision to use Runway 9

-22:03	2nd Officer:	"*CFIT is moderate and . . . .* " (CVR time 0515:14)
-18:47	1st Officer:	"*all right, start on down*" (CVR time 0518:30)
	<discussion>	Approximate block of time where crew briefing for a landing on runway 27 was accomplished, and descent initiated. Also, the crew was aware of the moderate CFIT risk rating for the Tallahassee airport.
-8:51	1st Officer:	"*we ever decide if we're goin nine or two seven?*" (CVR time 0528:26)
-8:49	Captain:	"*yeah, we can do nine if you want to.*" (CVR time 0528:28)
-8:47	1st Officer:	"*okay runway nine, visual runway nine PAPI on the left hand side …approach check.*" (CVR time 0528:30)
-8:42	2nd Officer:	"*briefing?*" (CVR time 0528:35)
-8:41	Captain:	"*complete for runway nine.*" (CVR time 0528:36)
	<discussion>	The crew discussed the possibility of landing runway 9 for several minutes. The statements listed above are the point where the decision to actually switch to runway 9 for the landing was made, and with only a cursory supplementary briefing.

Runway Lighting

-2:42	Captain:	"*there we go*" (CVR time 0534:35)
	<discussion>	Captain acknowledges that the runway & PAPI lights had illuminated. Note that three separate attempts were made by the crew to activate the pilot controlled runway and PAPI lights at -15:10, -6:45 and -2:46. This is the first indication in the CVR transcript that the crew could actually see that the lights were illuminated. This would indicate the PAPI visual glideslope aide was illuminated less than three minutes prior to first tree impact.

Glideslope

-0:47	FDR data:	the airplane completes a left turn to line up with the runway heading, marking the beginning of final approach.
-0:28	1st Officer:	*"(I'm) gonna have to stay just a little -* (CVR time 0536:49) *- bit higher, (or) I'm gonna lose -* (CVR time 0536:50) *- the end of the runway.*" (CVR time 0536:51)
-0:08	Captain:	"*it's startin' to disappear in there a little bit, idn't it*", (CVR time 0537:09)
0:00	CAM:	*[sound of clunk]* (CVR time 0537:15)
	<discussion>	Both the Captain and First Officer seem to recognize that they may be low, however, there is no indication on the FDR data that any action was taken to correct the perception. Additionally, there is no discussion of the PAPI indications on the CVR.

KNOWLEDGE GAINED DURING THE INVESTIGATION

The following summarizes knowledge gained that is pertinent to drawing conclusions:

- The crew chose to use the non-ILS equipped runway 9, even though runway 27 was available with an operational ILS.
- Only a cursory supplementary briefing was accomplished for runway 9 after the decision was made to change runways. The benefit of a full briefing is the opportunity to review the hazards and requirements associated with the planned approach. This was a CFIT awareness opportunity lost.
- Runway 9 at Tallahassee Regional Airport is upsloped from the runway threshold and requires an approach over an undeveloped forest which may appear as a black hole in darkness. This upslope and the black hole effect are common factors that can lead to CFIT during a night visual approach.
- The airplane systems (flaps/slats, flight controls, GPWS, etc) were functioning normally during the landing sequence. Neither the installed GPWS nor an EGPWS would have generated a ground proximity alarm.
- The airplane was functioning normally during the landing sequence. The roll to the right that resulted in the right wingtip contacting the ground occurred as a result of impact with the trees.
- The PAPI visual glideslope aide was illuminated less than three minutes prior to first tree impact.
- During final approach, both the Captain and First Officer seem to recognize that they may be low, however, there is no evidence on the FDR data that any action was taken to correct the perception. No discussion of the PAPI indications were recorded by the CVR.

CONCLUSIONS

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

- This was a CFIT accident in which the flight crew did not recognize that the airplane was flying considerably below the expected approach path. Possible contributors to this low approach were the visual perceptions associated with an upsloped runway and the black hole effect. In addition, the cursory supplementary briefing for runway 9 represented a CFIT awareness opportunity lost.

RECOMMENDATIONS

Boeing makes the following recommendation based on the knowledge gained:

- When available, the use of instrument landing aids should be encouraged for all approaches at night or in low visibility conditions, especially at airports identified as a CFIT risk. This is not intended to be an airplane restriction but rather a prudent operational risk reduction measure.

BOEING ACTIONS

Boeing has a longstanding history of a proactive role within industry in educating flight crews about CFIT. The following articles have been published in Boeing publications:

Boeing Airliner Magazine
- Mar-Apr 1969 issue: "Night Visual Approaches"
- Apr-Jun 1979 issue: "Airfield Lights and the Simulator Visual Scene"
- Jan-Feb 1985 issue: "Approach and Landing, Back to Basics"
- Oct-Dec 1986 issue: "Flight Path Control"
- Apr-Jun 1987 issue: "Control of the Crew Caused Accident"
- Oct-Dec 1990 issue: "Non-Precision Approach"
- Jan-Feb 1991 issue: "The Last Two Minutes"
- Apr-Jun 1991 issue: "Visual Approaches"
- Jan-Feb 1994 issue: "Black Hole Approach"
- Apr-Jun 1996 issue: "Avoiding Controlled Flight Into Terrain"

Boeing Aero Magazine
- July 2002 issue: "Tools for the Reduction of Approach and Landing Accidents"
- October 2002 issue: "Vertical Situation Display"

Boeing remains committed to continuing to actively participate with industry to work toward eliminating CFIT accidents altogether. These activities include:

- Development and incorporation of the enhanced situational awareness Vertical Situation Display.
- An EGPWS is a basic feature on current Boeing production airplanes. In addition, Boeing provides support for retrofit of EPGWS in airplanes already in-service.
- Active participation in the development of Flight Safety Foundation's Approach and Landing Accident Reduction (ALAR) toolkit. The project is focused on actions to eliminate CFIT and other types of approach and landing accidents. Boeing has distributed the ALAR toolkit to all Boeing Customers. Boeing continues to work on worldwide implementation of the ALAR concepts through presentations at worldwide seminars and through the encouragement of regional safety actions.
- Active participation and leadership of the U.S. Commercial Aviation Safety Team. This partnership activity between the industry and the FAA has led to detailed analysis of both CFIT and approach and landing accidents. Boeing is committed to implementing the interventions that have been identified and agreed to by this team activity. Boeing also actively supports and encourages the European JAA Safety Strategy Initiative as well as the regional implementation of these interventions around the world.
- Co-leadership of the Flight Safety Foundation CFIT Task Force created in the early 1990's to generate an international approach to addressing CFIT accidents. This effort led to the development of the CFIT Training Aid and the CFIT Training video, both produced by Boeing for this international task force effort. Boeing has also translated the video into other languages in order to facilitate the dissemination and understanding of the material around the world.