Crash During Approach to Landing, Air Tahoma, Inc., Flight 185, Convair 580, N586P, Covington, Kentucky, August 13, 2004

Micro-summary: **This Convair 580 crashed short of the airport, due to fuel exhaustion.**

Event Date: **2004-08-13 at 0049 EDT**

Investigative Body: **National Transportation Safety Board (NTSB), USA**

Investigative Body's Web Site: **http://www.ntsb.gov/**

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Crash During Approach to Landing
Air Tahoma, Inc., Flight 185
Convair 580, N586P
Covington, Kentucky
August 13, 2004

Aircraft Accident Report

NTSB/AAR-06/03

PB2006-910403
Notation 7778

National Transportation Safety Board
Washington, D.C.

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Adopted May 2, 2006

National Transportation Safety Board
490 L'Enfant Plaza, S.W.
Washington, D.C. 20594

National Transportation Safety Board. 2006. *Crash During Approach to Landing, Air Tahoma, Inc., Flight 185, Convair 580, N586P, Covington, Kentucky, August 13, 2004.* Aircraft Accident Report NTSB/AAR-06/03. Washington, DC.

Abstract: This report explains the accident involving Air Tahoma, Inc., flight 185, a Convair 580, N586P, that crashed about 1 mile south of Cincinnati/Northern Kentucky International Airport, Covington, Kentucky, while on approach to runway 36R. Safety issues discussed in this report focus on flight crew performance, fuel crossfeed operations, operating with different fuel boost pump output pressure settings, and cockpit voice recorder power source reliability. Safety recommendations concerning these issues are addressed to the Federal Aviation Administration. A safety recommendation concerning operating with different fuel boost pump output pressure settings is addressed to Transport Canada.

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Abbreviations

A&P	airframe and powerplant
AFM	aircraft flight manual
agl	above ground level
ARTS	automated radar terminal system
ASOS	automated surface observing system
ATC	air traffic control
ATCT	air traffic control tower
ATP	airline transport pilot
CAM	cockpit area microphone
CFR	*Code of Federal Regulations*
CG	center of gravity
CVG	Cincinnati/Northern Kentucky International Airport
CVR	cockpit voice recorder
DME	distance measuring equipment
FAA	Federal Aviation Administration
FARs	*Federal Aviation Regulations*
FDR	flight data recorder
FOM	flight operations manual
fpm	feet per minute
GOM	general operations manual
GPWS	ground proximity warning system
lbs	pounds
MEM	Memphis International Airport
MSAW	minimum safe altitude warning
NDB	nondirectional beacon
NPRM	notice of proposed rulemaking

PIC	pilot-in-command
PJCB	Prop-Jet Convair Bulletin
PPI	Pacific Propeller, Inc.
psi	pounds per square inch
QRH	quick reference handbook
SDR	service difficulty report
STC	supplemental type certificate
TC	Transport Canada
TRACON	terminal radar approach control
TSB	Transportation Safety Board of Canada
VOR	very high frequency omnidirectional range

Executive Summary

On August 13, 2004, about 0049 eastern daylight time, Air Tahoma, Inc., flight 185, a Convair 580, N586P, crashed about 1 mile south of Cincinnati/Northern Kentucky International Airport (CVG), Covington, Kentucky, while on approach to runway 36R. The first officer was killed, and the captain received minor injuries. The airplane was destroyed by impact forces. The flight was operating under the provisions of 14 *Code of Federal Regulations* Part 121 as a cargo flight for DHL Express from Memphis International Airport, Memphis, Tennessee, to CVG. Visual meteorological conditions prevailed for the flight, which operated on an instrument flight rules flight plan.

The National Transportation Safety Board determines that the probable cause of this accident was fuel starvation resulting from the captain's decision not to follow approved fuel crossfeed procedures. Contributing to the accident were the captain's inadequate preflight planning, his subsequent distraction during the flight, and his late initiation of the in-range checklist. Further contributing to the accident was the flight crew's failure to monitor the fuel gauges and to recognize that the airplane's changing handling characteristics were caused by a fuel imbalance.

The safety issues discussed in this report include flight crew performance, fuel crossfeed operations, operating with different fuel boost pump output pressure settings, and cockpit voice recorder power source reliability. Safety recommendations concerning these issues are addressed to the Federal Aviation Administration. A safety recommendation concerning operating with different fuel boost pump output pressure settings is addressed to Transport Canada.

1. Factual Information

1.1 History of Flight

On August 13, 2004, about 0049 eastern daylight time,[1] Air Tahoma, Inc., flight 185, a Convair 580, N586P, crashed about 1 mile south of Cincinnati/Northern Kentucky International Airport (CVG), Covington, Kentucky, while on approach to runway 36R. The first officer was killed, and the captain received minor injuries. The airplane was destroyed by impact forces. The flight was operating under the provisions of 14 *Code of Federal Regulations* (CFR) Part 121 as a cargo flight for DHL Express[2] from Memphis International Airport (MEM), Memphis, Tennessee, to CVG. Visual meteorological conditions prevailed for the flight, which operated on an instrument flight rules flight plan.

The flight crew was scheduled to fly the accident airplane on a roundtrip sequence from MEM to CVG.[3] Flight 185 departed MEM about 2329. The first officer was the flying pilot, and the captain performed the nonflying pilot duties. During postaccident interviews, the captain stated that the takeoff and climb portions of the flight were normal.

According to the cockpit voice recorder (CVR) transcript, at 0017:49, the captain stated that he was just going to "balance out the fuel here."[4] The first officer acknowledged. From 0026:30 to 0027:08, the CVR recorded the captain discussing the airplane's weight and balance with the first officer. Specifically, the captain stated, "couldn't figure out why on the landing I was out and I was okay on the takeoff." The captain added, "the momentum is one six six seven and I…put one zero six seven and I couldn't work it." He then stated, "so…we were okay all along."[5]

At 0030:40, the first officer stated, "weird." At 0032:31, the captain stated, "okay just let me finish this [the weight and balance paperwork] off and…I'm happy," and, about 2 minutes later, he stated, "okay, back with you here." At 0037:08, the captain contacted Cincinnati Terminal Radar Approach Control (TRACON) and reported an altitude of 11,000 feet mean sea level.[6] About 1 minute later, the first officer stated, "something's messed up with this thing," and, at 0039:07, he asked "why is this thing?" At 0041:21, the

[1] Unless otherwise indicated, all times in this report are eastern daylight time.

[2] Under a lease agreement, Air Tahoma supplied flight crews and airplanes to DHL to carry freight between several cities on a scheduled basis.

[3] The roundtrip sequence departed MEM every night, Monday through Friday, about 2300. The return flight typically departed CVG about 0400.

[4] Fuel crossfeeding operations are conducted by the flight crew to balance out the fuel in the airplane's fuel tanks. For more information about fuel crossfeed operations procedures, see section 1.17.2.

[5] For more information about the airplane's weight and balance and the captain's calculations see section 1.6.3.

[6] Unless otherwise indicated, all altitudes in this report are referenced in mean sea level.

first officer stated that the control wheel felt "funny." He added, "feels like I need a lot of force. it is pushing to the right for some reason. I don't know why…I don't know what's going on." The first officer then repeated twice that it felt like he needed "a lot of force." The CVR did not record the captain responding to any of these comments.

At 0043:53, when the airplane was at an altitude of about 4,000 feet, the captain reported to Cincinnati TRACON that he had the runway in sight. The approach controller cleared flight 185 for a visual approach to runway 36R and added, "keep your speed up."[7] The captain acknowledged the clearance and the instruction. The first officer then stated, "what in the world is going on with this plane? sucker is acting so funny." The captain replied, "we'll do a full control check on the ground." At 0044:43, the approach controller again told the captain to "keep your speed up" and instructed him to contact the CVG Air Traffic Control Tower (ATCT).

At 0045:11, the captain contacted the CVG ATCT and requested clearance to land on runway 36R, and the local control west controller issued the landing clearance. Flight data recorder (FDR) data indicated that, shortly afterward, the airplane passed through about 3,200 feet, and its airspeed began to decrease from about 240 knots indicated airspeed. At 0045:37, when the airplane was at an altitude of about 3,000 feet, the captain started the in-range checklist,[8] stating, "bypass is down. hydraulic pressure. quantity checks. AC [alternating current] pump is on. green light. fuel panel. boost pumps on."

About 0046, the first officer stated, "I'm telling you, what is wrong with this plane? it is really funny. I got something all messed up here." The captain replied, "yeah." The first officer then asked, "can you feel it? it's like swinging back and forth." The captain replied, "we've got an imbalance on this…crossfeed I left open." The first officer responded, "oh, is that what it is?" A few seconds later, the first officer stated, "we're gonna flame out." The captain responded, "I got the crossfeed open. just keep power on."

At 0046:45, the CVR recorded a sound similar to decreasing engine rpm. Immediately thereafter, the first officer stated, "we're losing power." At 0046:52, the first officer stated, "we've lost both of them. did we?" The captain responded, "nope." FDR data showed that, about 1 second later, a momentary electrical power interruption occurred when the airplane was at an altitude of about 2,400 feet. At 0046:55, the CVR stopped recording. Airplane performance calculations indicated that, shortly after the power interruption, the airplane's descent rate was about 900 feet per minute (fpm).

According to air traffic control (ATC) transcripts, at 0047:12, the captain reported to the CVG ATCT that the airplane was "having engine problems." The local control west controller asked, "you're having engine problems?" The captain replied, "affirmative." At

[7] During postaccident interviews, the approach controller stated that he instructed the flight crew to "keep the speed up" because he thought that Air Tahoma flight crews had a tendency to decrease the airspeed too early in the approach and that he wanted to prevent that from occurring.

[8] Air Tahoma's Flight Operations Manual (FOM) states that the in-range checklist should be performed before "leaving 12,000 feet" and that "early completion [of the checklist] will minimize cockpit distractions." The in-range checklist includes a step to check the fuel panel settings. For a schematic of the Convair 580 fuel panel, see section 1.6.2.1, figure 2.

0047:28, the controller asked the captain if he needed emergency equipment, and the captain replied, "negative.'" This was the last transmission received by ATC from the accident flight crew. The FDR continued recording until about 0049. The wreckage was located about 1.2 miles short of runway 36R.

1.2 Injuries to Persons

Table 1. Injury chart.

Injuries	Flight Crew	Cabin Crew	Passengers	Other	Total
Fatal	1	0	0	0	1
Serious	0	0	0	0	0
Minor	1	0	0	0	1
None	0	0	0	0	0
Total	2	0	0	0	2

Note: Title 14 CFR 830.2 defines a serious injury as any injury that (1) requires hospitalization for more than 48 hours, starting within 7 days from the date that the injury was received; (2) results in a fracture of any bone, except simple fractures of fingers, toes, or the nose; (3) causes severe hemorrhages or nerve, muscle, or tendon damage; (4) involves any internal organ; or (5) involves second- or third-degree burns or any burns affecting more than 5 percent of the body surface. A minor injury is any injury that does not qualify as a fatal or serious injury.

1.3 Damage to Airplane

The airplane was destroyed by impact forces.

1.4 Other Damage

Trees and a portion of a golf course along the wreckage path were damaged by the impact.

1.5 Personnel Information

1.5.1 The Captain

The captain, age 49, was hired by Air Tahoma on July 19, 2004. The captain held both Federal Aviation Administration (FAA)- and Transport Canada (TC)-issued pilot licenses and certificates.[9] The captain's FAA-issued certificates included an airframe and powerplant (A&P) certificate (issued February 25, 1982), a flight engineer certificate (issued January 26, 1988),[10] and a multiengine airline transport pilot (ATP) certificate

[9] The captain is a citizen of Canada.

(issued February 11, 2003) with a Convair 340/440 type rating (issued May 9, 2003).[11] The captain held a first-class FAA airman medical certificate, dated April 16, 2004, with the limitation that he "must possess glasses for near vision." The captain's TC-issued certificates included a flight engineer certificate (issued December 28, 1983) and a commercial pilot certificate (issued May 7, 1997). The captain had Canadian aircraft (type) ratings in the Convair 580 and the Lockheed L-1011. Table 2 shows the employment information reported by the captain on the job application that he filled out for Air Tahoma.

Table 2. Employment information for the captain.

Employment date	Employer	Job position	Airplane type
1981 to 1983	Chevron Corporation, Khartoum, Sudan	Maintenance engineer	Convair 580
1983 to 1985	Northwest Territorial Airways, Yellowknife, Northwest Territories, Canada	Flight engineer	Lockheed Electra
1985 to 1987	Nationair, Montreal, Canada	Flight engineer	Douglas DC-8
1987 to 1993	Gulf Air Airlines, Bahrain, United Arab Emirates, and All Nippon Airways, Tokyo, Japan	Flight engineer	Lockheed L-1011
April 1993 to December 2003	Air Transat, Montreal, Canada	Flight engineer/first officer[a]	Lockheed L-1011
1998 (6 months)	Air Wave Transport, Toronto, Canada	First officer	Convair 580
1999 to 2003 (several months per year)[b]	Nolinor Aviation, Montreal, Canada	First officer	Convair 580
November 2002 to July 2003	Coastal Air Transport, Mobile, Alabama	Captain	Convair 580
Summer 2003	ConAir, Abbotsford, British Columbia, Canada	First officer	Convair 580

[a] The captain began working for Air Transat as a flight engineer. He upgraded to first officer in May 1999. He flew a total of about 104 hours before cutbacks at Air Transat caused him to return to the flight engineer position. In December 2003, the captain failed a first officer requalification proficiency checkride, and he chose to receive a severance package from Air Transat rather than return to the flight engineer position.

[b] While working at Air Transat, the captain took leave to fly under contract as first officer or captain for various companies.

[10] The flight engineer certificate was a special purpose lessee with the limitation that the certificate was valid for U.S.-registered civil Lockheed L-1011s leased to Gulf Air Airlines, Bahrain, United Arab Emirates. The certificate was issued under and subject to 14 CFR 63.23 and subject to the privileges and limitations shown on the holder's foreign flight engineer certificate, license, or authorization.

[11] The FAA uses the rating designation "Convair 340/440" on a pilot's airman certificate when the pilot is rated in the Convair 340/440 or the Convair 580.

Air Tahoma records indicated that the captain had accumulated 2,500 total flight hours, including 1,337 hours in the Convair 580, 88.5 hours of which were as pilot-in-command (PIC). He had flown about 32, 28, and 2 hours in the 90 days, 30 days, and 24 hours, respectively, before the accident. The captain's last Convair 580 proficiency and line checks occurred on July 29, 2004. In accordance with 14 CFR 121.405(d), the captain attended an FAA-approved reduced training course at Air Tahoma because of his previous Part 121 experience in the Convair 580 at Coastal Air Transport. A search of FAA records indicated no accident or incident history or enforcement action, and a search of the National Driver Register found no record of driver's license suspension or revocation.

The captain stated that, during the 72 hours before the accident, he stayed at Air Tahoma's crew house in Memphis. He stated that he typically slept until about noon after returning from flights in the morning (about 0500 central daylight time). The captain stated that, on the day of the accident, he watched television from about 1600 to 2100 central daylight time and then checked in at MEM for the accident flight. The captain stated that he did not feel tired during the accident flight but that he was "preoccupied" with and "stressed" about calculating the airplane's weight and balance. A company mechanic who routinely met both the captain and the first officer before and after trips stated that they both appeared normal, alert, and "not dragging" before the accident flight. The captain stated that he was in good health and that he did not take any medications.

1.5.1.1 Flight Test Failure History

On February 7, 2003, the captain received a notice of disapproval from the FAA because he failed the precision instrument approach portion of the flight test for his ATP certificate. On February 11, 2003, the captain was retested successfully, and he received his ATP certificate. On May 8, 2003, the captain received a notice of disapproval from the FAA because he failed the nondirectional beacon (NDB) approach portion of the flight test for his Convair 580 type rating. On May 9, 2003, the captain was retested successfully, and he received his Convair 580 type rating.

1.5.2 The First Officer

The first officer, age 37, was hired by Air Tahoma on May 5, 2004. The first officer held an A&P certificate (issued May 8, 1996), a commercial pilot certificate with single- and multiengine land ratings (issued February 7, 2002), and a flight instructor certificate (issued April 10, 2002). The first officer held a first-class FAA airman medical certificate dated December 16, 2003, with no limitations. Table 3 shows the employment information reported by the first officer on the job application that he filled out for Air Tahoma.

Table 3. Employment information for the first officer.

Employment date	Employer	Job position	Airplane type
January 1997 to August 2001	Ryan International Airlines, Wichita, Kansas	Flight engineer	Boeing 727
April 2002 to March 2004	Douglas Aviation, Olive Branch, Mississippi	Flight instructor	N/A
July 2002 to April 2003	Air Venture Flying Club, Olive Branch, Mississippi	Flight instructor	Cessna 152 and 172
December 2002[a] to February 2004	Ryan International Airlines	Flight engineer	Boeing 727

[a] In August 2001, the first officer was laid off from Ryan International. In December 2002, Ryan International rehired him.

Air Tahoma and Ryan International records indicated that the first officer had accumulated 2,488 total flight hours, 1,564 hours of which were as a flight engineer, and 924 hours of which were as PIC or first officer. The first officer had accumulated 145 hours in Convair 580 airplanes. He had flown about 145, 70, and 2 hours in the 90 days, 30 days, and 24 hours, respectively, before the accident. The first officer's last Convair 580 proficiency and line checks occurred on May 26, 2004. FAA records indicated no accident or incident history or enforcement action, and a search of the National Driver Register found no record of driver's license suspension or revocation.

The first officer operated all of the flights from MEM to CVG from August 9 to 13, 2005, and all of these flights were in the accident airplane. According to a family member, on August 12, the first officer returned home about 0700 central daylight time and slept until about 1530 central daylight time. Later that day, he went to his son's football practice and ate dinner before checking in for the flight. A company mechanic reported that the first officer appeared to be wide awake and alert before the flight and that he had sufficient time to complete his preflight activities. The family member reported that the first officer did not use alcohol or take any medications.

1.5.2.1 Flight Test Failure History

On November 14, 2001, the first officer received a notice of disapproval from the FAA because he failed the steep turns, compliance with departure and arrival procedures, distance measuring equipment (DME) arc approach, and NDB approach portions of the flight test for his instrument rating. The first officer was retested successfully on November 19, 2001, and he received his instrument rating. On April 10, 2002, the first officer received a notice of disapproval from the FAA because he failed the ground reference maneuvers portion of the flight test for his flight instructor certificate. The first officer was retested successfully that day, and he received his flight instructor certificate.

1.6 Airplane Information

The accident airplane, serial number 068, was manufactured in 1953 by General Dynamics, Convair Division, and was originally designated "Convair 340/440." In 1967, the airplane was made to comply with Supplemental Type Certificate (STC) SA41100,[12] changing its designation to "Convair 580."[13]

Air Tahoma purchased the airplane from European Air Transport in Belgium on April 27, 2004; at which time, the airplane was flown to the company's maintenance facility at Rickenbacker International Airport, Columbus, Ohio. From April 28 to July 15, 2004, the airplane underwent a conformity and acceptance inspection, a C check (maintenance inspection), and serial number verification before being operated in the United States.[14] Maintenance records indicate that, during these inspections, most of the airplane's replaceable components were replaced because of inadequate time and service history information and that all of the fuel system components, except for the right fuel boost pump, were replaced with overhauled units.[15] The FAA issued a standard airworthiness certificate for the airplane on July 14, 2004. At the time of the accident, the airplane had accumulated about 67,886 total flight hours.

The accident airplane was configured with five containerized pallets in the fuselage for all-cargo operations.[16] There were four cargo stops (one in each of the floor tracks) at the aft and forward ends of the fuselage. Each cargo stop was secured to floor tracks in the airplane's interior by two latches. Four cargo locks, which raised up and locked the pallets into position, were between each pallet (16 locks total). Each lock was secured to the floor tracks by two latches.

In compliance with STC SA41100, the airplane was equipped with two Rolls-Royce 501-D13D turbopropeller engines. The time since new for the left engine was 41,232 hours, and the time since overhaul was 4,808 hours. The time since new for the right engine was 24,055 hours, and the time since overhaul was 1,858 hours. The airplane was equipped with Aeroproducts model A6441FN-606A propellers. The right propeller

[12] In 1960, STC SA41100 was developed to install two Rolls-Royce (formerly Allison Gas Turbines) 501-D13D turbopropeller engines on the Convair 340/440, and the airplane model's designation was changed to Convair 580. Currently, about 26 Convair 580 airplanes are in operation in the United States.

[13] General Dynamics, Convair Division, held the Convair 580 type certificate until 1995; at which time, the type certificate was transferred to Tracor Flight Systems. In 1998, the type certificate was transferred to Kelowna Flightcraft Ltd., British Columbia, Canada.

[14] The conformity and acceptance inspection was conducted in accordance with Air Tahoma's FARs [*Federal Aviation Regulations*] 121 Conformity Check and Acceptance Manual, dated January 8, 1999; the C check was performed in accordance with Air Tahoma's FAA-approved maintenance program; and the serial number verification was performed in accordance with Air Tahoma's FARs 121 Conformity CV-580 Serial Number Verification document.

[15] Maintenance records indicated that the right fuel boost pump had been replaced by Canadian Aero Accessories Ltd., Calgary, Alberta, Canada, in February 2003. For more information about the airplane's fuel system, see section 1.6.2.

[16] The Convair 580 was originally configured as a 52-seat passenger airplane.

was overhauled in January 2002, and the left propeller was overhauled in May 2003 by Pacific Propeller, Inc. (PPI),[17] Kent, Washington.

1.6.1 Electrical System

The airplane had a 28-volt d.c. electrical system and a 115/200-volt a.c. electrical system. The d.c. electrical system had two engine-driven power generators, and the a.c. electrical system had two engine-driven alternators. Each engine had one d.c. generator and one a.c. alternator. The electrical system was designed to automatically revert to battery power if both d.c. generators and a.c. alternators shut down in flight. When this occurs, the a.c. electrical system is powered by the batteries through the d.c. electrical system and an inverter.

1.6.2 Fuel System

The Convair 580 fuel system comprises two subsystems, one for each wing-mounted engine. Each fuel subsystem has a wing fuel tank, which is fueled through a fuel filler cap and mating adaptor located under a cover plate on the upper surface of each wing.[18] Fuel is supplied from each fuel tank via fuel lines, which pass through the tank wall, a fuel tank shutoff valve, and an electric fuel boost pump, to its respective engine. (Figure 1 shows a schematic of the Convair 580 fuel system.) The electric fuel boost pump supplies pressurized fuel to its respective engine and to the crossfeed fuel line. The fuel boost pump supplies fuel at an output pressure of about 15 to 21 pounds per square inch (psi) at a rate of about 640 gallons per hour. The airplane's two fuel subsystems are connected by a crossfeed system consisting of two electrically operated crossfeed valves, which allows both engines to be supplied with fuel from either fuel tank.[19]

[17] PPI holds the type certificate for the propellers.

[18] Each fuel tank has an 865-gallon capacity, four capacitance transmitters, and one compensator for fuel quantity indication in the cockpit.

[19] For information about Air Tahoma's fuel crossfeed procedures, see section 1.17.2.

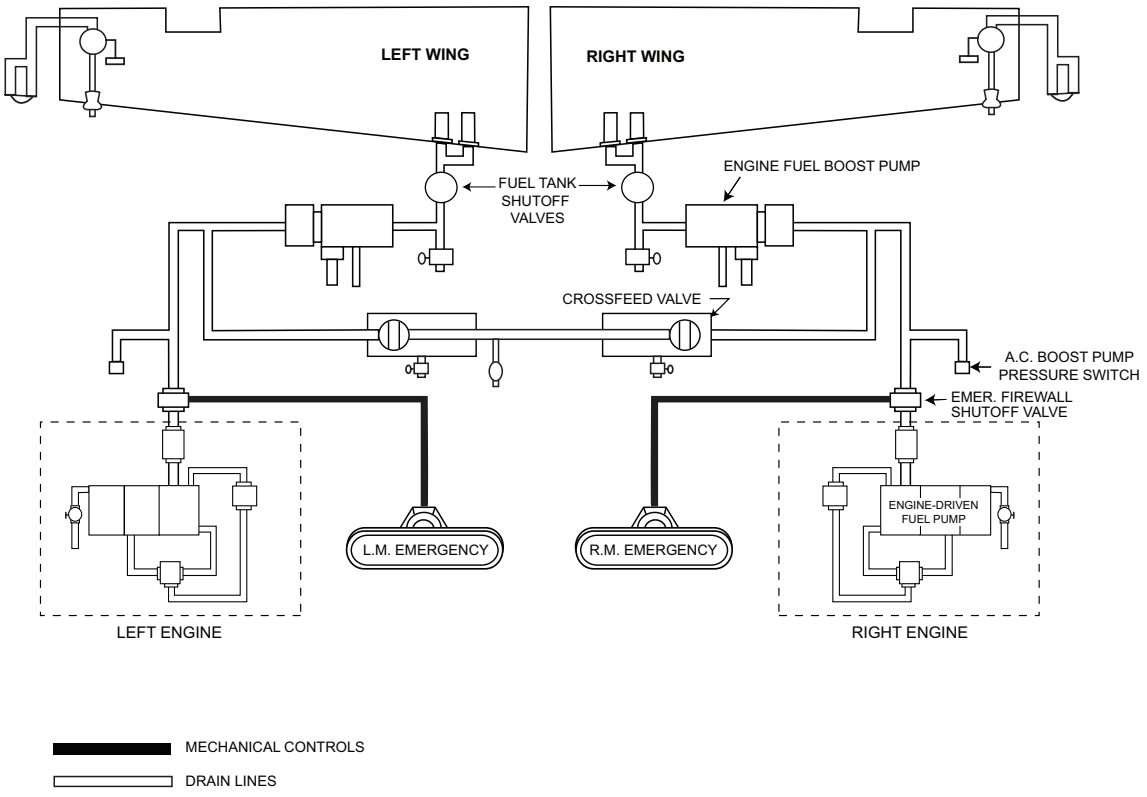

Figure 1. Schematic of the Convair 580 fuel system.

1.6.3 Fuel System Cockpit Instrumentation

The airplane's fuel system cockpit instrumentation includes the fuel panel, fuel quantity indicators, and fuel system warning annunciator lights. The fuel panel, which is located on the captain's overhead instrument panel, has an emergency power-off switch and three cover-guarded switches: two fuel tank shutoff valve switches and one fuel crossfeed valve switch. Figure 2 shows the Convair 580 fuel panel.

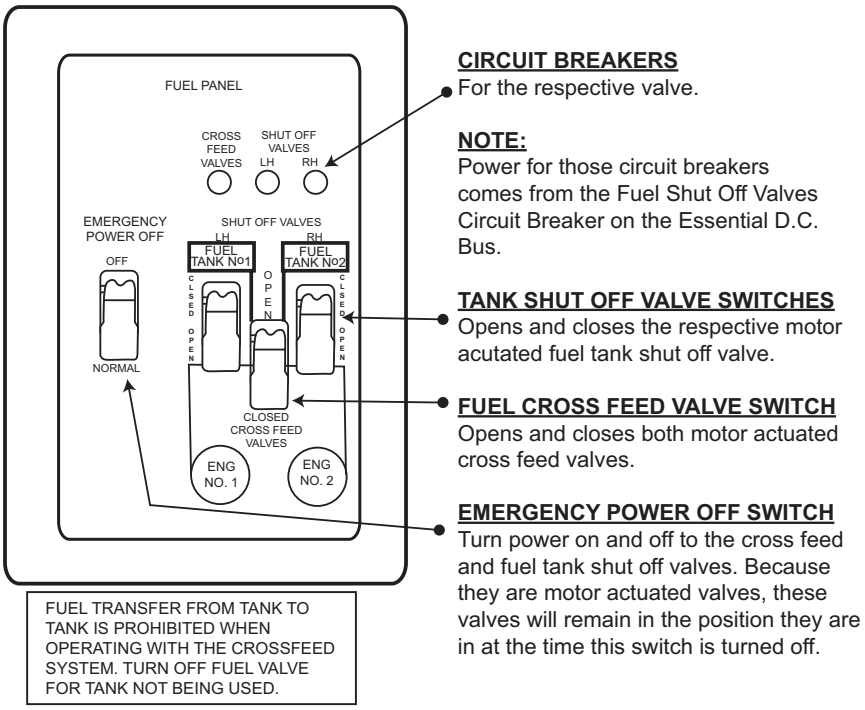

Figure 2. The Convair 580 fuel panel.

The fuel quantity indicators are located on the lower part of the center instrument panel and behind the center pedestal, which includes the engine throttle control console and the gust lock levers. (Figure 3 shows the fuel quantity indicators behind the center pedestal.) The three fuel system warning annunciator lights for each engine (primary fuel pump failure, low engine fuel boost pressure, and aircraft fuel boost pressure) are located on the center pedestal annunciator panel.

Figure 3. The Convair 580 fuel quantity indicators and center pedestal.

Postaccident interviews with Air Tahoma personnel and an inspection of another Convair 580 revealed that, at some seat positions, it was difficult to see the fuel quantity indicators. Specifically, if the seats were in an aft position, the indicators were difficult to see because the throttle control console and the gust lock lever partially blocked the indicators. The inspection revealed that, in the aft position, a pilot had to sit up and lean forward to completely see the fuel quantity indicators.

1.6.3.1 Fuel System Limitations

The FAA-approved Aircraft Flight Manual (AFM), dated April 5, 1962,[20] contains the following caution:

> DO NOT ATTEMPT TO TRANSFER FROM ONE TANK TO ANOTHER. TO DO SO MIGHT BUILD UP EXCESSIVE PRESSURE IN A TANK, WHICH COULD RESULT IN STRUCTURAL FAILURE OR CAUSE FUEL TO OVERFLOW THROUGH THE VENTS.

[20] The AFM used by Air Tahoma was issued by the airplane manufacturer, General Dynamics, Convair Division.

The Convair 580 type certificate data sheet indicated that a placard stating, "Fuel transfer from tank to tank is prohibited. When operating with the crossfeed system, turn off fuel valve for tank not being used," must be displayed on the instrument panel in full view of the pilot. The Air Tahoma CV-580 Flight Operations Manual (FOM), Section 1.000, "Limitations," states that transferring fuel from one tank to another tank is prohibited and that crossfeeding fuel is prohibited during takeoff and landing (unless an engine cannot be fed from its respective tank). The manual states that the maximum permissible lateral fuel imbalance in flight is 2,080 pounds (lbs) and that the maximum demonstrated lateral fuel imbalance during takeoff and landing is 600 lbs.

1.6.3.2 Prop-Jet Convair Bulletin Regarding Fuel Boost Pump Output Pressures

Prop-Jet Convair Bulletin (PJCB) 10-21, "Aircraft Fuel Boost Pump Output Pressure Limit-Reduce," dated October 10, 1969, provided details on an optional procedure that allowed Convair operators to reduce the typical fuel boost pump output pressure setting of 21 psi to 15 psi. The bulletin stated that reducing the output pressure would "improve the service life of the aircraft fuel boost pump motors." The bulletin also stated that the low fuel boost pump pressure warning switch would have to be replaced with a switch that would actuate at a decreasing pressure of 9 psi and an increasing pressure of 10 psi. The bulletin stated that, although aircraft could be operated with different fuel boost pump output pressure settings and switches, "preferably, aircraft should be operated with identical boost pump pressure settings and switches, of either configuration, on both sides."

Postaccident examinations revealed that the accident airplane's right fuel boost pump was set to an output pressure of 15 psi[21] and that its left fuel boost pump was set to an output pressure of 20 psi. Air Tahoma stated that it was unaware of PJCB 10-21, and, therefore, was not aware of the possibility that its Convair 580 airplanes were operating with different fuel boost pump output pressure settings. In its July 18, 2005, submission, Air Tahoma indicated that, after the accident, the company checked all of its airplanes' fuel boost pump pressure output pressure settings and switches and set all of the output pressure settings to 21 psi.

1.6.4 Weight and Balance Information

Title 14 CFR 121.665, "Load Manifest," states, in part, the following:

> Each certificate holder is responsible for the preparation and accuracy of a load manifest form before each takeoff. The form must be prepared and signed for each flight by employees of the certificate holder who have the duty of supervising the loading of aircraft and preparing the load manifest forms or by other qualified persons authorized by the certificate holder.

[21] Examinations also revealed that the airplane's right low boost pump pressure warning switch was set at 9 psi. For more information about the postaccident fuel boost pump examinations, see section 1.16.1.

Title 14 CFR 121.693, "Load Manifest: All Certificate Holders," states, in part, that the load manifest must contain the weight of the aircraft, fuel and oil, cargo and baggage, passengers, and crewmembers; the maximum allowable weight for the flight; the total weight calculated using FAA-approved company procedures; and evidence that the aircraft was loaded in accordance with an approved schedule that ensures that the CG is within limits. Title 14 CFR 121.695, "Disposition of Load Manifest, Dispatch Release, and Flight Plans: Domestic and Flag Operations," states, in part, that the pilot must carry copies of the completed load manifest, dispatch release, and flight plan in the airplane.

Two load manifests were found at the accident site; however, the captain did not leave a load manifest at the departure station, which is required by company procedures and Federal regulations.[22] The captain stated during postaccident interviews that he usually left a yellow copy of the load manifest at the departure station. However, the captain stated that he did not leave a copy of the load manifest at MEM before the accident flight departed because he had to manually calculate the airplane's weight and balance, and the calculations were not completed before takeoff.[23]

The captain left a signed copy of a load sheet,[24] which showed the weight of the cargo loaded in each of the airplane's five cargo containers (labeled A through E) and the location at which each container should be loaded on the airplane, with the cargo loaders at MEM. He stated that the total cargo weight was not near the maximum allowable. He added that the load was "an average load" and that he used his "general experience" to determine whether the airplane was within weight and balance limits before takeoff. For example, the captain stated that, during the preflight check, he noted that the airplane sat "properly" on the nose landing gear strut.

Both load manifests found at the accident site had the accident flight number, accident flight date, and numerous crossouts on them. One of the manifests was not signed by the captain and indicated weights and cargo locations that corresponded to those on the load sheet he left at MEM. The other load manifest was signed by the captain and did not indicate weights and cargo locations that corresponded to those on the load sheet. Table 4 shows the information listed on each of the load manifests found at the accident site.

[22] For more information about Air Tahoma's procedures on the preparation and disposition of weight and balance paperwork, see section 1.17.1.

[23] Air Tahoma's handheld company computer was not working before the flight departed. Air Tahoma's ground school instructor stated the captain was not trained to manually compute an airplane's weight and balance because he had attended the company's reduced training course. In its submission, Air Tahoma indicated that, after the accident, the company provided followup training to its flight crewmembers on how to compute weight and balance with and without the handheld computer and emphasized the importance of leaving a copy of the weight and balance paperwork at the departure station.

[24] The load sheet that the captain left at MEM was not an official document nor was it mentioned in company manuals or procedures; rather, it was an informal document used between Air Tahoma flight crews and cargo loaders.

Table 4. Accident airplane weight and balance information.

	Unsigned load manifest	Signed load manifest
Cargo weight (pounds)	12,400	12,400
Fuel weight (pounds)	7,600	7,900
Takeoff weight (pounds)	54,213[a]	54,513
Takeoff moment/1,000[b]	21,073	21,118
Takeoff center of gravity (CG) limits (moment/1,000)[c]	19,638 (forward)/20,386 (aft)	20,571 (forward)/21,283 (aft)
Fuel burn (pounds)	4,200	4,200
Fuel burn moment/1,000	1,067/1,667[d]	1,667
Landing weight (pounds)	50,013	50,313
Landing moment/1,000	20,030/19,430[e]	19,451
Landing CG limits (moment/1,000)	18,752 (forward)/19,529 (aft)	18,872 (forward)/19,645 (aft)

[a] According to Air Tahoma's Convair 580 Cargo Weight & Balance Loading Manual, the maximum certificated takeoff weight for the accident airplane was 58,156 lbs.

b A moment is a force that tries to cause rotation and is the product of weight (in pounds) and distance from the CG (in inches).

[c] Using the CV-580 CG Limits Table contained in the Air Tahoma loading manual and assuming a takeoff weight of about 54,200 lbs, Safety Board investigators determined that the takeoff CG limits for the accident flight were about 20,408 forward and 21,127 aft.

[d] The fuel burn moment appeared to have been written as 1,067 and then rewritten as 1,667. According to Air Tahoma's Convair 580 Cargo Weight & Balance Loading Manual, the correct moment for a fuel burn of 4,200 lbs was 1,667.

[e] The landing moment of 20,030 corresponds to the originally written fuel burn moment of 1,067, and the landing moment of 19,430 corresponds to the rewritten fuel burn moment of 1,667.

1.7 Meteorological Information

Weather observations at CVG were made every hour by an automated surface observing system (ASOS).[25] About 0015, the ASOS reported that visibility was 10 statute miles, clouds were overcast at 7,500 feet above ground level (agl), and winds were 320° at 5 knots.

1.8 Aids to Navigation

The DME on the CVG VOR[26] was inoperative. No problems with any other navigational aids were reported.

[25] ASOS is a system that continuously measures weather information, including wind speed and direction, visibility, precipitation, cloud cover, temperature, dew point, and altimeter setting.

[26] VOR stands for very high frequency omnidirectional range.

1.9 Communications

No communications problems between the pilots and any of the air traffic controllers who handled the accident flight were reported.

1.10 Airport Information

CVG is located about 9 miles south of Cincinnati, Ohio, at an elevation of 896 feet. The airport has three runways: runway 18L/36R, 18R/36L, and 9/27. All of the runways have high-intensity runway and centerline lights. Runway 18L/36R has a standard 2,400-foot, high-intensity lighting system with sequenced flashers[27] and a precision approach path indicator on its right side.

CVG is equipped with an automated radar terminal system (ARTS)-IIIA radar data processing system, which includes a minimum safe altitude warning (MSAW) capability that monitors aircraft separation from terrain and other obstacles. If an aircraft descends below or is predicted to descend below a prescribed minimum altitude, the MSAW provides air traffic controllers with both visual and aural alerts. The minimum altitude at which the MSAW alerts controllers varies according to geographic location. CVG's ARTS-III system did not activate an MSAW alert around the time of the accident.[28]

1.11 Flight Recorders

1.11.1 Cockpit Voice Recorder

The accident airplane was equipped with a Honeywell Sundstrand V557 model CVR, serial number 2372. The exterior of the CVR was not structurally damaged. The CVR was sent to the Safety Board's laboratory in Washington, D.C., for readout and evaluation. The tape was played back normally and without difficulty. The recording started at 0016:03 and continued until 0046:55.

The recording consisted of three separate channels of audio information: the captain and first officer audio panels and the cockpit area microphone (CAM). The captain audio panel information was excellent quality, the first officer audio panel information was good quality, and the CAM information was poor quality.[29] A transcript was prepared of the entire 30-minute, 52-second recording (see appendix B).

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[27] A notice to airmen recorded by the CVR at 0030:41 indicated that the sequenced flashers on runway 36R were out of service.

[28] Radar coverage of the accident airplane should have been available to the ground; however, the airplane descended below radar coverage before the ARTS-III system could detect whether the airplane was below the minimum safe altitude or predict whether it would descend below the minimum safe altitude.

[29] The Safety Board rates the quality of CVR recordings according to a five-category scale: excellent, good, fair, poor, and unusable. See appendix B for a description of these ratings.

1.11.1.1 Cockpit Voice Recorder Power Source

Title 14 CFR 121.359(a) requires airplanes to be equipped with a CVR system that operates "continuously from the start of the use of the checklist (before starting engines for the purpose of flight) to completion of the final checklist at the termination of the flight." The CVR on the accident airplane was installed in 1966 by Allegheny Airlines, Inc., Middleton, Pennsylvania, in accordance with Engineering Order 66-16c, Revision A, which required changing the wiring "to provide an isolated power source for the [CVR]…to comply with FAR [*Federal Aviation Regulations*] 121.359."

The accident CVR was designed to receive sufficient power to operate when both engine power levers are at or above flight idle. When the engine power levers are in the low-speed range or shut down and the low-rpm buttons, which are located on the center pedestal, are pushed in by the flight crew, the low-rpm relays are energized, and the batteries provide power to the CVR.[30] However, when both engines are in the low-speed range or shut down and the low-rpm buttons are not pushed in by the pilot, no power is provided to the CVR.

1.11.1.2 Safety Recommendation A-99-16

On March 9, 1999, as a result of its longstanding concerns about the loss of critical flight information following interruption of electrical power to the CVR or FDR, the Safety Board issued Safety Recommendation A-99-16,[31] which asked the FAA to do the following:

> Require retrofit after January 1, 2005, of all CVRs on all airplanes required to carry both a CVR and an FDR with a CVR that…is capable of recording the last 2 hours of audio, and…is fitted with an independent power source that is located with the digital CVR and that automatically engages and provides 10 minutes of operation whenever aircraft power to the recorder ceases, either by normal shutdown or by a loss of power to the bus.

The safety recommendation letter cited the investigation of the September 2, 1998, Swissair flight 111 accident, which was conducted by the Transportation Safety Board of Canada (TSB) with the participation of the Safety Board,[32] as the most recent investigation that had been "severely hampered" by the lack of critical flight information and noted that "Since 1983, there have been 52 accidents and incidents in which

[30] When the engine power levers are moved from the low-speed range to a higher speed range, power is automatically removed from the low-rpm relays, the low-rpm buttons are automatically released, and the CVR transitions to electrical power from the engine alternators. Most turbopropeller airplanes have battery-operated CVR systems and are not equipped with circuitry like that installed on the accident airplane.

[31] In 1999, Safety Recommendation A-99-16 was placed on the Safety Board's List of Most Wanted Transportation Safety Improvements. For more information about Safety Recommendation A-99-16 and the Most Wanted list, see the Board's Web site at <http://www.ntsb.gov>.

[32] In accordance with the provisions of Annex 13 to the Convention on International Civil Aviation, the Safety Board participated in the TSB's investigation as the representative of the State of Design and Manufacture.

information from either the CVR or FDR or both were lost due to interruption of electrical power following an engine or generator failure or crew action."

In a March 19, 1999, letter, the FAA stated that it would issue a notice of proposed rulemaking (NPRM) to address Safety Recommendation A-99-16. In a July 21, 2001, letter, the Safety Board stated that the FAA had made little progress to address the recommendation since its issuance 2 years previously. Therefore, the Board classified Safety Recommendation A-99-16 "Open—Unacceptable Response," pending issuance of an NPRM and expeditious issuance of a final rule.

On February 28, 2005, the FAA published an NPRM titled, "Revisions to Cockpit Voice Recorder and Digital Flight Data Recorder Regulations," which proposed requiring that all CVRs record a minimum of 2 hours of audio information. The NPRM stated that all newly manufactured aircraft would be required to be equipped with a 2-hour CVR within 2 years of the issuance of a final rule and that all existing aircraft would be required to be retrofitted with a 2-hour CVR within 4 years of the issuance of the rule. The NPRM also proposed a requirement to install a 10-minute independent power source for CVRs on newly manufactured aircraft.

In an April 29, 2005, letter, the Safety Board stated that it was pleased about the FAA's proposed actions to require 2-hour CVRs on all aircraft within 4 years. However, the Board stated that it was disappointed that the proposed requirement to install a 10-minute independent CVR power source only applied to newly manufactured aircraft. The Board suggested that the FAA require the installation of an independent CVR power source on all aircraft within 4 years of the final rule. Safety Recommendation A-99-16 remains classified "Open—Unacceptable Response," pending the suggested rule change.

1.11.2 Flight Data Recorder

The accident airplane was equipped with a Honeywell model 980-4100 FDR, serial number 7657 that used a magnetic tape as the recording medium. The FDR system was designed to record six parameters.[33]

The FDR was sent to the Safety Board's laboratory for readout and evaluation. The FDR was found to be in good condition, and the data were extracted normally. About 25 hours of data were recorded by the FDR, including data for the accident flight. About 0047, the airplane's electrical power was interrupted, which caused a momentary dropout of the FDR data. The FDR stopped recording about 0049.

[33] Turbine-powered, transport-category aircraft manufactured on or before October 11, 1991, are required to be equipped with an FDR that records a minimum of 11 parameters in accordance with 14 CFR 121.344. However, the accident FDR only recorded six parameters. The six parameters recorded and verified were time, airspeed, pressure altitude, vertical load factor, magnetic heading, and microphone keying.

1.11.3 Safety Recommendation A-00-30

On April 11, 2000, as a result of longstanding concerns about the loss of critical flight recorder data, the Safety Board issued Safety Recommendation A-00-30, which asked the FAA to do the following:

> Require that all aircraft operated under…14 *Code of Federal Regulations* Part 121, 125, or 135 and currently required to be equipped with a cockpit voice recorder (CVR) and digital flight data recorder (DFDR) be retrofitted by January 1, 2005, with a crash-protected cockpit image recording system.[34] The cockpit image recorder system should have a 2-hour recording duration, as a minimum, and be capable of recording, in color, a view of the entire cockpit including each control position and each action (such as display selections or system activations) taken by people in the cockpit. The recording of these video images should be at a frame rate and resolution sufficient for capturing such actions. The cockpit image recorder should be mounted in the aft portion of the aircraft for maximum survivability and should be equipped with an independent auxiliary power supply that automatically engages and provides 10 minutes of operation whenever aircraft power to the cockpit image recorder and associated cockpit camera system ceases, either by normal shutdown or by a loss of power to the bus. The circuit breaker for the cockpit image recorder system, as well as the circuit breakers for the CVR and the DFDR, should not be accessible to the flight crew during flight.

In a March 29, 2004, letter, the FAA stated that flight recorder-related safety recommendations continued to be difficult to respond to in a manner that the Safety Board would find acceptable. The FAA also stated that flight recorder-related safety recommendations presented unique challenges, including difficulties in cost/benefit analysis, technical hurdles, retrofit problems, data use issues, and privacy concerns.

On June 3, 2004, FAA and Safety Board staff met to discuss previously issued flight recorder-related safety recommendations, including Safety Recommendation A-00-30. In a December 15, 2004, letter, the Safety Board noted that, although the meeting was constructive, the substance of the safety recommendations and the FAA's planned actions in response to them were not discussed; therefore, the Board classified Safety Recommendation A-00-30 "Open—Unacceptable Response."

In its April 29, 2005, response to the February 2005 flight recorder-related NPRM, the Safety Board stated that it was disappointed that the FAA had not addressed image recorders in the NPRM. The Board also stated that image recorders would have provided in-depth information about the facts, conditions, and circumstances surrounding numerous accidents. The Board restated its opinion that image recorders could play a key role in accident investigations by providing critical human performance and cockpit environment information that would otherwise be unavailable. The Board encouraged the FAA to move

[34] Image recorders obtain audio information (similar to that recorded by CVRs), event data (similar to that recorded by FDRs), and information about the environment inside the cockpit and outside the cockpit window.

quickly to implement Safety Recommendation A-00-30. On January 24, 2006, the Safety Board reiterated Safety Recommendation A-00-30 as a result of its investigation of the October 19, 2004, Corporate Airlines flight 5966 accident in Kirksville, Missouri.[35]

1.12 Wreckage and Impact Information

1.12.1 General Wreckage Description

The airplane initially impacted the top of a stand of trees, which exhibited a few clean, angled cuts, about 40 feet agl. The airplane impacted the ground about 308 feet north of the initial impact point. The airplane then impacted a grove of trees about 420 feet from the initial impact point, where the aft fuselage came to rest, about 1.2 miles short of the approach end of runway 36R. The forward fuselage was scattered about 200 feet beyond the edge of the grove. The total wreckage path was about 600 feet long.

The forward half of the airplane and most of the wing structure were destroyed. The airplane's forward fuselage was found essentially split in half about a vertical plane that extended from the nose to near the wing rear spar. The right half of the forward fuselage remained partially attached to the rear fuselage but was severely damaged by impact forces. Most of the left half of the forward fuselage was found severed from the rest of the airplane and in several sections within the debris field. The section of the fuselage from the wing rear spar to the tail, which included the inboard halves of both horizontal stabilizers and the entire vertical stabilizer and rudder, was found intact, oriented on about a 60° magnetic heading, and banked about 30° left wing down. The forward portion of this section exhibited severe impact damage.

The right engine remained attached to the right wing and was found embedded in a tree. The right propeller hub had separated from the engine and was found in the main debris field. The left engine remained attached to the left wing and was found adjacent to the cockpit at the forward end of the main debris field. The left propeller hub was found in the main debris field. The compressor blades showed very little evidence of tip curling or bending in the direction opposite of rotation. All of the turbine blades and nozzles were found intact and showed no signs of metal spray.

The engines were disassembled at Rolls-Royce's facility in Indianapolis, Indiana, under Safety Board direction. Examinations of both engines revealed no evidence of uncontainment or burnthrough. Several compressor blades exhibited foreign object damage on the trailing edges in the direction of engine rotation. Finely chopped or pulverized green vegetative debris was found throughout both engines. The vegetative debris showed no evidence of burning or charring. Pulverized dirt was found throughout the left engine. The turbine blades and nozzles were intact on both engines; however, the

[35] For more information about this accident, see National Transportation Safety Board, *Collision with Trees Short of the Runway, Corporate Airlines Flight 5966, British Aerospace BAE-J3201, N875KX, Kirksville, Missouri, October 19, 2004,* Aircraft Accident Report NTSB/AAR-06/01 (Washington, DC: NTSB, 2006).

left engine's turbine vanes exhibited leading and/or trailing edge damage. No evidence of any metal spray or splatter was found on any of the engines' turbine blades.

The propellers were disassembled at PPI's facility in Kent, Washington, under Safety Board direction. Six of the eight propeller blade angles were measured to have been from about 40° to 46° at the time of impact.[36] Examinations revealed that one of the four right propeller blades and three of the four left propeller blades had sheared off. All of the fracture surfaces showed signatures consistent with overload, with no leading edge or rotational damage.

The airplane's two batteries were found in the battery compartment on the underside of the left wing, and both batteries exhibited substantial impact damage. The ground proximity warning system (GPWS) unit, which is powered by the essential d.c. electrical system, was found with the Mode 4 (flight into terrain when not in landing configuration) warning button indicator activated.[37]

Four of the five cargo containers were destroyed by impact forces. The fifth container was found intact in the aft fuselage section, and its base was deformed upward. Three of the four forward cargo stops were found intact but separated from the floor tracks. The fourth forward cargo stop was found attached to its floor track. The four aft cargo stops were found intact and attached to their floor tracks. All of the recovered cargo locks exhibited damage consistent with impact.

1.12.2 Fuel Tank System Components and Controls

Both fuel cap access doors were found closed and latched. Both fuel filler caps were found unlocked and were able to be lifted away without any counter-clockwise rotation.[38] The operating mechanism for the left fuel filler cap exhibited wear. A functional check was performed on the left fuel filler cap, and, during several attempts to engage, several complete clockwise turns were required to lock the cap in place. When the cap was successfully engaged, very little counter-clockwise pressure was required to loosen the cap. A functional check was performed on the right fuel filler cap, and it operated normally.

After the accident, Air Tahoma inspected the condition and installation of the fuel filler caps on its other Convair airplanes, and no discrepancies were noted. In its July 2005 submission, Air Tahoma indicated that, after the accident, all company mechanics and Air Tahoma-contracted fuel vendors were trained on over-wing fuel filler cap installation and fueling procedures. Air Tahoma indicated that the company instructed flight

[36] Two of the blades' angles could not be determined because of accident damage.

[37] If a warning mode activates in flight, one of five warning mode button indicators on the annunciator panel will change from black to green and yellow. If power to the GPWS is lost, the warning button indication will remain visible.

[38] Fuel filler caps are removed during fueling operations. Normal engagement of the fuel filler cap requires the cap to be rotated about a quarter turn clockwise to lock into place securely.

crewmembers to ensure that the proper type and amount of fuel was added and that, during preflight inspections and at intermediate stops, the fuel filler caps were secure.

The fuel boost pump low and primary fuel failure warning circuit breakers were found open. The left fuel boost pump circuit breaker was found open, and the right fuel boost pump circuit breaker was found closed.[39]

Impact damage precluded a continuity check between the fuel tanks and the crossfeed lines. The left and right main fuel tank shutoff valve switches and the left and right crossfeed valves were found in the open position. The emergency power-off switch guard was broken off, and the switch was found in the off position.

The left fuel quantity indicator was found indicating 0 lb of fuel. The right fuel quantity indicator's glass face was broken, and the fuel quantity indicator was found indicating about 5,600 lbs of fuel. According to Kelowna Flightcraft, the Convair 580 type certificate holder, the fuel quantity indication in the cockpit can indicate a fuel quantity that is from 300 to 500 gallons greater than the actual amount, depending on the airplane's roll attitude.

The signed load manifest showed that the accident airplane had about 8,000 lbs of fuel on board at takeoff.[40] The manifest showed a fuel burn of about 4,200 lbs, which would have left about 3,800 lbs of fuel on board at the time of impact. Air Tahoma provided the Safety Board with the flight releases and fueling records for the accident airplane's 12 previous flights from MEM to CVG. Using fuel data from these records, Board investigators calculated that the fuel burn for the accident airplane's last 12 flights ranged from about 3,500 to 4,200 lbs.

1.13 Medical and Pathological Information

Fluid specimens obtained from the pilot and fluid and tissue specimens from the first officer were transported to the FAA's Civil Aerospace Medical Institute for toxicological analysis. The specimens tested negative for alcohol and a wide range of drugs, including major drugs of abuse.[41]

1.14 Fire

No evidence of an in-flight or a postcrash fire was found.

[39] For information about postaccident examinations and bench tests of the accident fuel boost pumps, see section 1.16.1.1.

[40] A copy of an Aircraft Service International Group aircraft service record indicated that, on the day of the accident, company ground personnel added 3,564 lbs of fuel to the accident airplane's fuel tanks.

[41] The drugs tested in the postaccident analysis include (but are not limited to) marijuana, cocaine, opiates, phencyclidine, amphetamines, benzodiazapines, barbiturates, antidepressants, antihistamines, meprobamate, and methaqualone.

1.15 Survival Aspects

According to the Boone County Coroner's Office autopsy report, the cause of death for the first officer was "massive acute body trauma." According to the captain's medical records, he sustained minor injuries, including multiple lacerations, acute right lower extremity contusions, and acute bilateral forearm contusions.

1.16 Tests and Research

1.16.1 November 2004 Fuel Boost Pump Examinations and Testing

On November 16 and 17, 2004, the fuel boost pump assemblies were examined and bench tests were conducted at Canadian Aero Accessories Ltd.'s facility in Calgary, Alberta, Canada, under Safety Board supervision. The exterior and the interior components of the left electrically driven fuel boost pump and respective electric pump motor exhibited no signs of damage or wear. The cooling fan on the pump motor was clean, with no visible damage. The pump motor cooling fan could be rotated by hand with no binding. The pump motor operated normally when power was applied.

The top and front of the right fuel boost pump assembly exhibited some damage. The internal components of the right fuel pump exhibited no signs of damage or wear. The pump motor cooling fan cover and the fan blade directly beneath the dented portion of the cover were found bent inward. None of the other fan blades exhibited damage, nor were any rotational markings found. The pump motor cooling fan could be rotated by hand with little resistance, and the pump motor operated normally when power was applied.

During the bench tests, the left fuel boost pump was determined to be operable within the manufacturer's delivery specifications and maintained an output pressure of 20 psi. The right fuel boost pump was initially found to have an output pressure of 15 psi, which was allowed by the issuance of PJCB 10-21.[42] The output pressure setting screw was then adjusted to the manufacturer's delivery specifications; at which point, the right fuel boost pump maintained an output pressure of 20 psi. Air Tahoma indicated that the left and right fuel boost pump output pressures were not measured or altered after the company bought the airplane in 2004.

1.16.2 April 2005 Fuel Boost Pump Testing

On April 12 and 13, 2005, bench tests using the accident airplane's right fuel boost pump were conducted at Argo-Tech Corporation's facility in Cleveland, Ohio. The fuel boost pump tests simulated crossfeed operation from the left fuel tank, through a

[42] Initially, Safety Board investigators and Convair 580 maintenance personnel thought that the 15-psi output pressure setting had resulted from the impact.

nonoperating right fuel boost pump and an open right fuel tank shutoff valve, consistent with the airplane's approximate fuel system configuration during the last portion of the accident flight. The tests revealed that, with the left fuel boost pump output pressure set at 21 psi, the right engine's fuel tank shutoff valve open, and both fuel crossfeed valves open, the fuel not consumed by the right engine was allowed to flow back through the right fuel boost pump and into the right fuel tank.

1.17 Organizational and Management Information

Air Tahoma began Part 121 cargo operations on May 21, 1997. At the time of the accident, Air Tahoma had 50 employees, including 15 pilots and a fleet of four Convair 240 and four Convair 580 airplanes. The company operated cargo flights daily from MEM; Cleveland and Columbus, Ohio; and Pittsburgh, Pennsylvania, to CVG.

1.17.1 Flight Paperwork Procedures

Air Tahoma's FAA-approved General Operations Manual (GOM), Section 1.617, "Disposition of Documents," stated, in part, the following:

> If a flight originates at a place other than the Principal Operations Base, the Captain will fax a copy of Flight Release and the weight and balance manifest to the company…If the aircraft departs a station where there is a person authorized by the Company who manages the departure, and who does not depart on the aircraft, then that person or the crew may retain the signed copies of the required documents in a designated location.

Air Tahoma's GOM, Section 1.741, "Preflight Procedures," stated that a flight plan form, which is incorporated in the flight release form, must be completed by the flight crew before a company aircraft departs for a flight or series of flights. The GOM stated that weight and balance calculations for the flight plan form "will be computed on an approved weight and balance form" and added the following

> The completed [form] will be attached to both copies of the flight release form…A copy of the Flight Release…and Weight and Balance form…will be faxed, or mailed to [Air Tahoma] Operations. If there is no fax available then…self-addressed envelopes…can be used. The envelope will be given to the FBO [fixed-base operator] to be mailed if there is no mailbox available.

1.17.2 Air Tahoma Fuel Crossfeed Procedures

Air Tahoma's CV-580 Quick Reference Handbook (QRH), dated February 5, 1997, contains fuel crossfeed procedures, which state, in part, the following:

> CROSSFEED FROM EITHER TANK TO OPPOSITE ENGINE
>
> 1 BOTH FUEL BOOST PUMPS ..... ON

2 BOTH AIRCRAFT FUEL BOOST PRESSURE LIGHTS ..... OFF

3 CROSSFEED VALVE..... OPEN

4 FUEL BOOST PUMP FOR TANK NOT TO BE USED ..... OFF

IF EITHER OR BOTH AIRCRAFT FUEL BOOST PRESSURE LIGHTS ARE ILLUMINATED:

- BOTH FUEL BOOST PUMPS.....ON
- RESET AS REQUIRED

CROSSFEED VALVE C/B [CIRCUIT BREAKER] (OVERHEAD PANEL)

- FUEL SHUT OFF VALVE C/B
- FUEL BOOST PUMP C/B
- FUEL BOOST PUMP FOR TANK NOT TO BE USED ..... OFF

IF EITHER OR BOTH AIRCRAFT FUEL BOOST PRESSURE LIGHTS ARE ILLUMINATED:

- AIRCRAFT BOOST PUMPS.....AS REQ
- CROSSFEED VALVE..... CLOSED
- DO NOT CROSSFEED
- END

5 TANK SHUTOFF VALVE FOR TANK NOT USED..... OFF

During postaccident interviews, the captain stated that he had previously performed fuel crossfeed operations about 5 to 10 times in the Convair 580. The captain stated that fuel crossfeed operations were always performed to correct an in-flight fuel imbalance. The captain stated that Air Tahoma trained company pilots to use the QRH during fuel crossfeed operations.[43]

According to the company's chief pilot, pilots were trained to crossfeed fuel only in safety-of-flight situations. He stated that, because the company typically operated short flights, from 1 to 1.5 hours long, any in-flight fuel imbalance could be corrected during ground fueling operations.[44] Interviews of other company pilots revealed that they did not routinely crossfeed fuel in flight. However, a Safety Board review of Air Tahoma's operations and training manuals revealed that the company had no written documentation regarding fuel crossfeed operations restrictions.

[43] A company ground school instructor indicated that, because the captain attended the reduced training course, he received "more of a review" of the fuel crossfeed operations procedures.

[44] Kelowna Flightcraft indicated that it also had a policy to restrict fuel crossfeed operations to safety-of-flight situations because the company only operated short flights.

The captain stated that he thought that the fuel tank shutoff valve should not be turned off during fuel crossfeed operations because, if the shutoff valve could not be reopened, the fuel in that tank would not be accessible. The captain thought that his two previous employers did not require that the fuel tank shutoff valve be closed during fuel crossfeed operations.[45] The captain also thought that the Convair 580 had a one-way check valve that would prevent fuel from transferring from one tank to another tank during crossfeed operations.[46]

Postaccident interviews with Air Tahoma's chief pilot and Nolinor Aviation personnel revealed that additional pilots believed that the Convair 580 fuel tank shutoff valve had a tendency to fail. Further, a Kelowna Flightcraft maintenance instructor stated that, during company training, he had been asked about fuel tank shutoff valve failures. He believed that this concern led many pilots to leave the fuel tank shutoff valve open. The instructor stated that he thought that the pilots' concerns were unfounded because, in the previous 10 years, no customers had reported any fuel tank shutoff valve failures.[47]

1.17.2.1 Airplane Manufacturer Fuel Crossfeed Procedures

The airplane manufacturer's AFM contains the following fuel crossfeed procedures:

> (1) place boost pump switch for tank being used to the ON position and place the crossfeed switch to the ON position, (2) place the boost pump switch for the tank not being used to the OFF position, and (3) place the fuel shutoff valve switch for the tank not being used to the CLOSED position.

As noted previously, the procedures also contain a caution stating that transferring fuel from one tank to the other is prohibited because structural failure or overflow of fuel through the vent system could occur.

1.17.2.2 Nolinor Aviation Fuel Crossfeed Procedures

Nolinor Aviation, one of the captain's previous employers, operated five Convair 580 airplanes, none of which had a one-way fuel check valve installed in the fuel system. At the time of the accident, Nolinor Aviation's fuel crossfeed operations procedures, which were contained in the company's FOM (dated February 14, 1998), included a step indicating that the fuel tank shutoff valve on the tank not being used should be closed, "subject to the captain's discretion." The company's QRH did not

[45] The investigation revealed that one of the captain's previous employers, Nolinor Aviation, did not require that the fuel tank shutoff valve be closed during crossfeed operations. For additional information about Nolinor Aviation's fuel crossfeed procedures, see section 1.17.2.2.

[46] One-way check valves are not typically installed on airplanes, and the accident airplane did not have one installed. According to a Kelowna Flightcraft representative, one Convair 580 operator modified its fleet of about 30 Convair 580 airplanes in the 1960s under an engineering order by installing a one-way check valve, which prevented fuel from flowing back into the fuel tanks when the fuel tank shutoff valve was left open. However, the representative stated that this operator was no longer in business and that its airplanes had represented a small percentage of the entire Convair 580 fleet.

[47] Further, a search of the FAA's service difficulty reports (SDR) database revealed no history of Convair 580 fuel tank shutoff valve failures.

include this remark. According to Nolinor Aviation's chief pilot, in November 2004, the company corrected the discrepancy between its QRH and FOM by removing the remark, "subject to the captain's discretion," from the fuel crossfeed operations procedures contained in the FOM.

1.17.3 Air Tahoma Engine Flameout Procedures

The Air Tahoma CV-580 QRH contains emergency flameout procedures (loss of one or both engines), which state, in part, the following:

1. AIRSPEED ..... MAINTAIN 170 KTS

IF RPM 5500-6500 RPM:

POWER LEVER(S)1" [INCH] ABOVE FLIGHT IDLE

FUEL VALVES ..... CAPPED

FUEL BOOST PUMPS ..... ON

FEATHER BUTTON ..... PUSH TO 2500 RPM, THEN PULL

PRIMER ..... HOLD UNTIL LIGHT OFF

E-HANDLE ..... IDENTIFY & GUARD

When the accident airplane was about 4.5 miles from the runway and at an altitude of about 2,300 feet,[48] the flight crew reported to the CVG ATCT that they were having engine problems. During postaccident interviews, the captain could not remember if the airplane had experienced an engine problem or whether he had performed any emergency or abnormal procedures during the accident flight.

1.17.4 Postaccident Actions

On August 26, 2004, Air Tahoma issued Operations Memorandum 2 to all flight crewmembers to reemphasize which procedures to follow during fuel crossfeed operations. The memorandum stated, in part, that crossfeeding should only be conducted if it is necessary for the safety of flight; the QRH should be used during crossfeeding; a checklist should be placed in the throttle quadrant as a reminder that fuel crossfeeding was in progress; instruments should not be blocked by checklists; and crew resource management must be practiced and communications forceful, if necessary. Air Tahoma also stated that its captains had been instructed to physically touch the fuel panel when it is

[48] The terrain height in the accident area was about 900 feet.

called on the checklist rather that just looking at it.[49] In addition, Air Tahoma installed a breakaway wire on all of its Convair 580 fuel tank shutoff and crossfeed valve cover-guarded switches.[50]

Further, Air Tahoma stated that it had installed captain-side, overhead red lights, which indicate the position of the fuel crossfeed and fuel tank shutoff valve switches. When the left and/or right fuel tank shutoff valve switches are in the off (closed) position, the respective lights will illuminate, and when the fuel crossfeed valve switch is in the on (open) position, the respective light will illuminate. During normal operations, the fuel tank shutoff valve switches are on and the fuel crossfeed valve switch is off, resulting in all three lights being extinguished. Air Tahoma noted that the lights indicate crossfeed or fuel tank shutoff valve switch position not operation status.

1.18 Additional Information

1.18.1 Previous Convair 580 In-Flight Fuel Imbalance Incident

On September 21, 2004, a Nolinor Aviation Convair 580 had to return to its departure airport in Montreal, Canada, because of a fuel imbalance. The incident flight crew stated that, shortly after takeoff, a flight attendant reported that a passenger had seen fuel coming out of the right wing. The flight crew reported that, about this time, they needed to move the aileron to the left to maintain level flight, which required about a 10°-left input on the control wheel, and the fuel quantity indicators showed that the left and right fuel tanks had 4,000 and 6,000 lbs of fuel, respectively.[51] The flight crew stated that at this point, they noticed that the fuel crossfeed valve was open. The flight crew closed the fuel crossfeed valve and decided to return to Montreal, where they landed safely. The flight crew stated that the airplane was controllable at all times and that the fuel imbalance did not exceed the in-flight limit of 2,080 lbs.

Ground maintenance personnel determined that no fuel was coming out of the airplane's wing; however, it appeared that some fuel had been pumped overboard through the fuel vent system. The maintenance personnel also determined that the right and left fuel boost pumps had output pressure settings of 15 and 21 psi, respectively.[52] According to Nolinor Aviation, the left fuel boost pump had been replaced before the incident flight.

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[49] Operations Memorandum 2 also stated that, if excessive trim is needed to maintain normal flight, a problem might exist. Air Tahoma's chief pilot stated that the company did not have any training procedures related to control wheel imbalance but that he expected pilots to actively troubleshoot such a problem and to consider fuel imbalance as a possible cause.

[50] A breakaway wire is a device that supplements a cover-guarded switch and passively warns pilots that using the fuel switches in flight is nonroutine. If a flight crew used the breakaway wire in flight, maintenance personnel would have to replace it.

[51] According to Nolinor Aviation's chief pilot, the incident airplane was fueled to 11,200 lbs before takeoff.

[52] Nolinor Aviation indicated that it normally operated company airplanes with a fuel boost pump output pressure setting of 15 psi.

Nolinor indicated that company maintenance personnel did not bench check the replacement fuel boost pump before installing it on the airplane; therefore, the company did not know that the airplane was operating with different fuel boost pump output pressure settings. In addition, the maintenance personnel left the fuel crossfeed valve open after performing postinstallation checks on the left fuel boost pump.

2. Analysis

2.1 General

The captain and first officer were properly certificated and qualified under Federal regulations.

No evidence indicated that flight crew fatigue was a factor in this accident, and no evidence indicated any preexisting medical or behavioral conditions that might have affected the accident flight.

The airplane was properly maintained in accordance with Federal regulations and approved company procedures.

The recovered components showed no evidence of any preexisting powerplant, system, or structural failures. No evidence indicated that any of the airplane's cargo shifted during the flight.

Neither the weather nor the inoperative DME on the CVG VOR was a factor in this accident.

A review of the preflight fueling log, the signed load manifest found at the accident site, and previous flight information for the accident airplane revealed that there was sufficient fuel on board the airplane for the flight from MEM to CVG.

This analysis discusses the captain's preflight actions and the accident sequence, including the role of the flight crew's performance. This analysis also discusses the Convair 580 fuel system, including fuel crossfeed operations; the dual engine power loss; operating with different fuel boost pump output pressure settings; and independent CVR power sources.

2.2 The Captain's Preflight Actions

Air Tahoma's procedures and Federal regulations require that a flight crewmember prepare, complete, and leave a copy of the load manifest at the departure station. The captain did not leave a copy of the load manifest for the accident flight at MEM. However, two load manifests, one signed by the captain and the other unsigned, were found at the accident site.

A review of the unsigned load manifest and CVR transcript information revealed that, during manual, preflight weight and balance calculations,[53] the captain used the

[53] As mentioned previously, the captain had to manually complete the weight and balance calculations before takeoff because the handheld computer typically used by Air Tahoma's pilots to make these calculations was not working.

incorrect fuel burn moment value (1,067 instead of 1,667).[54] Because of this error, the captain's calculations showed the airplane outside of acceptable weight and balance limits. The captain stated during postaccident interviews that, although his preflight calculations showed the airplane outside of weight and balance takeoff limits, he used his "general experience" (for example, he stated that he looked at the nose landing gear strut extension) to determine that the airplane was within limits. On the basis of his observations, he decided to take off and finish the weight and balance paperwork during the flight.

A review of the signed load manifest and CVR transcript information revealed that the captain used the correct fuel burn moment value (1,667) on this manifest. The captain's calculations using the correct moment value indicated that the airplane was within acceptable weight and balance limits. Safety Board investigators verified the captain's recalculations. The Safety Board concludes that the captain's preflight weight and balance calculations indicated that the airplane was not within takeoff limits; therefore, he should not have allowed the airplane to take off. However, the captain's calculations were incorrect, and the airplane's weight and balance were within limits.

2.3 Accident Sequence

The accident flight departed MEM about 2329. Postaccident interviews with the captain and an examination of FDR data indicated that the takeoff, climb, and cruise portions of the flight (up to the time that the CVR transcript started) were uneventful. At 0017:49, the captain told the first officer that he was going to "balance out the fuel,"[55] and the first officer acknowledged.

At 0026:30, the captain told the first officer that he had been working on the weight and balance calculations since departing MEM. At 0032:31 (about 15 minutes after initiating the fuel crossfeed operations), the captain stated that he was finishing up the weight and balance calculations. Two minutes later, he stated, "okay, back with you here." During postaccident interviews, the captain stated that, because he was busy calculating the airplane's weight and balance, he was "preoccupied" and "stressed" during the flight. Although the weight and balance calculations were not difficult, because the captain used the incorrect fuel burn moment value, the calculations were not computing correctly, and the captain became preoccupied with trying to identify the mistake.

From 0038:22 to 0044:16, the first officer repeatedly told the captain that the airplane was not handling well. Specifically, he stated numerous times that the control wheel was requiring a "lot of force." The captain did not respond to the first officer's first five comments regarding the airplane's unusual handling characteristics, which occurred over a period of less than 6 minutes. The captain did not request clarification or elaboration from the first officer nor did he initiate any troubleshooting or take over the

[54] The fuel burn moment value appeared to have been written as 1,067 and then rewritten as 1,667. The captain used an estimated fuel burn of 4,200 lbs in his calculations. The correct fuel burn moment value for a fuel burn of 4,200 lbs is 1,667.

[55] Fuel crossfeed operations are used to balance out the fuel in an airplane's fuel tanks.

flight controls to independently validate the first officer's observations; instead, the captain remained silent, changed the subject, or was distracted by normal flight communications. At 0044:32, the captain finally responded to the first officer by telling him that they would perform a "full control check on the ground."

The PIC has final command authority in the cockpit and is responsible for the safety of the flight. It is reasonable to expect that, as part of the command responsibilities, the PIC would promptly investigate a potential flight control system anomaly reported by another flight crewmember. Unusual changes in an airplane's handling characteristics can possibly affect the safety of flight. Typically, one of the first actions taken to determine the cause of an airplane's changing handling characteristics would be to check for a possible fuel imbalance. Because the captain did not respond promptly to the first officer's comments, he missed several opportunities to recognize that the airplane's fuel was imbalanced. The Safety Board concludes that the captain did not recognize the importance of the cues provided by the first officer, and he failed to perform expected PIC duties.

At 0045:37, shortly after the airplane passed through 3,200 feet, the captain started the in-range checklist, which includes a step to check the fuel tank shutoff and crossfeed valve switch positions. Air Tahoma's FOM indicates that the in-range checklist should be started before leaving 12,000 feet and that "early completion [of the checklist] will minimize cockpit distractions." Therefore, the captain should have started the in-range checklist about 14 minutes earlier (shortly before 0035; at which time, the airplane was at an altitude of about 12,000 feet, and the first officer had not yet stated his concerns about the airplane's unusual handling characteristics).

While performing the in-range checklist, the captain stated that they had an "imbalance on this…crossfeed I left open." This was the only comment recorded by the CVR regarding fuel crossfeed operations since the captain started the operation almost 30 minutes earlier. Further, the CVR did not record any comments by either flight crewmember indicating that they were monitoring the airplane's fuel quantity. If the flight crewmembers had been monitoring the gauges, they would have seen unmistakable indications of a developing fuel imbalance. The fuel imbalance developed over a 30-minute period, and, as noted, during that time, the pilots had several opportunities to recognize and correct the problem; however, they failed to do so.

The Safety Board concludes that the captain was preoccupied with the weight and balance calculations during critical portions of the flight and, as a result, he did not monitor the fuel crossfeed operations, which resulted in a fuel imbalance and unusual airplane handling characteristics. The Safety Board further concludes that the flight crew did not monitor the fuel quantity gauges or respond properly to the airplane's changing handling characteristics, and the captain did not start the in-range checklist at the appropriate altitude; as a result, the crew missed several opportunities to identify the ongoing fuel crossfeed operations and determine that the airplane's fuel was imbalanced.

At 0046:35, the first officer stated, "we're gonna flame out." The captain responded, "I got the crossfeed open." The first officer then stated, "we're losing power," and, "we've lost both of them [engines]." The captain replied, "nope." The CVR stopped

recording at 0046:55, and, about the same time, a momentary interruption in electrical power occurred. About 2 minutes later, the FDR stopped recording. Although Air Tahoma's QRH contained engine flameout procedures, the pilots most likely would not have had sufficient time or altitude to restart the engines because they lost power during short final approach.

2.4 Convair 580 Fuel Crossfeed Operations

The Convair 580 type certificate data sheet and Air Tahoma's FOM prohibit fuel transfer from one tank to the other while the airplane is on the ground or in flight. The type certificate data sheet also states, "When operating with the crossfeed system, turn off fuel valve for tank not being used," which would preclude fuel transfer. The AFM also prohibits the transfer of fuel from one tank to the other and cautions, "to do so might build up excessive pressure in a tank, which could result in structural failure or cause fuel to overflow through the vents."

Step 5 of Air Tahoma's QRH fuel crossfeed procedures states that the fuel tank shutoff valve for the fuel tank not being used must be closed during fuel crossfeed operations. Further, the Convair 580's overhead fuel panel has a placard on the bottom that states the same thing. However, the captain stated that he did not shut off the right fuel tank shutoff valve, and wreckage examinations confirmed that both the left and right fuel tank shutoff valves were open at impact. Postaccident fuel boost pump testing revealed that, in this configuration, all of the fuel from the left fuel tank not used by the engines could transfer into the right fuel tank in a relatively short period of time.

During postaccident interviews, the captain stated that he was aware of the step to close the fuel tank shutoff valve for the tank not being used. However, the captain added that he intentionally kept the valve open because he thought that Convair fuel tank shutoff valves tended to fail after being shut off, preventing the use of the fuel in the closed tank.[56] The captain also stated that a previous employer (Nolinor Aviation) allowed company pilots to decide whether or not to close the valve.[57] The Safety Board is concerned that Convair 580 pilots' mistaken belief that the fuel tank shutoff valves have a tendency to fail may cause these pilots to intentionally keep the fuel tank shutoff valves open during fuel crossfeed operations, which could allow fuel to transfer and cause either structural damage or fuel overflow.

The Safety Board concludes that, although fuel transfer is prohibited on the Convair 580 airplane, fuel transfer can occur during fuel crossfeed operations if the fuel tank shutoff valve for the tank not being used is left open. The Safety Board further

[56] During postaccident interviews, other Convair 580 pilots indicated that they also thought that Convair fuel tank shutoff valves tended to fail. However, manufacturer and FAA SDR data did not indicate a history of Convair fuel tank shutoff valve failures.

[57] At the time of the accident, Nolinor Aviation's FOM stated that the fuel tank valve on the tank to be shut off should be closed, "subject to the captain's discretion." After the accident, Nolinor removed this remark from the crossfeed procedures contained in its FOM.

concludes that all of the fuel from the airplane's left tank that was not used by the engines transferred into the right tank because the captain intentionally kept the right fuel tank shutoff valve open during fuel crossfeed operations, which was not in accordance with approved fuel crossfeed procedures. Therefore, to prevent similar accidents from occurring in the future, the Safety Board believes that the FAA should issue a flight standards information bulletin to all principal operations inspectors of Convair 580 operators that familiarizes operators with the circumstances of the Air Tahoma flight 185 accident, including the importance of closing the fuel tank shutoff valve for the tank not being used during fuel crossfeed operations.

2.5 Dual Engine Power Loss

The Safety Board considered why both engines lost power even though the right fuel tank had sufficient fuel for operation. Further, after the engines failed, the flight crew was still able to make transmissions to ATC, the GPWS alerted, and the FDR continued to record, indicating that the airplane still had partial electrical power.

Wreckage examinations indicated that, when the left fuel tank was exhausted of fuel, the left fuel boost pump most likely continued to operate, which allowed air to enter the fuel system and reduced the fuel pressure to the left and right engine-driven fuel pump inlets. If the captain had turned on the right fuel boost pump after he identified that he had left the crossfeed valve switch open, it is possible that the right engine would have received sufficient fuel pressure to continue to operate; however, there is no evidence that he did so. Specifically, the right fuel boost pump fan motor cooling fan cover and the blade directly beneath the cover were found bent inward, and no rotational markings were found, indicating that the right fuel boost pump was not operating at the time of impact. Postaccident testing of the left and right fuel pumps revealed no evidence of preexisting failures.

The Safety Board concludes that, during the airplane's descent to landing, the fuel in the left fuel tank, which was providing fuel to both engines, was exhausted because both engine-driven fuel pumps drew air from the left tank into the fuel system instead of fuel from the right tank, resulting in a dual-engine flameout.

2.6 Differential Fuel Boost Pump Output Pressures Settings

PJCB 10-21, "Aircraft Fuel Boost Pump Output Pressure Limit-Reduce," which was published in October 1969, provided details on an optional procedure that allowed Convair 580 operators to reduce the typical fuel boost pump output pressure setting of 21 psi to 15 psi to "improve the service life of the aircraft fuel boost pump." The bulletin stated that, although an aircraft could be operated with different boost pump output pressure settings, "preferably, aircraft should be operated with identical boost pump

pressure settings." Postaccident testing of the accident fuel boost pumps revealed that the left and right fuel boost pumps had output pressure settings of 20 and 15 psi, respectively.

Air Tahoma maintenance personnel reported that they were not aware of PJCB 10-21 or the provision to lower the fuel boost pump output pressure setting to 15 psi. In June 2004, Air Tahoma replaced the left fuel boost pump on the accident airplane with a pump that had an output pressure setting of 21 psi. However, Air Tahoma did not replace the right fuel boost pump and did not measure or alter the output pressure setting. As a result, Air Tahoma was unaware that it was operating the airplane with different left and right fuel boost pump output pressure settings. The Safety Board is concerned that other Convair 580 operators may not be aware of PJCB 10-21 and its provision to allow fuel boost pumps to be set at different output pressure settings.

On September 21, 2004, a Nolinor Aviation Convair 580 experienced an in-flight fuel imbalance. The incident flight crew reported that a passenger had seen fuel coming from the right wing and that, about the same time, the fuel quantity indicators showed that the left and right fuel tanks had 4,000 and 6,000 lbs of fuel, respectively. The flight crew closed the fuel crossfeed valve after noticing that the valve was open. Nolinor Aviation ground maintenance personnel determined that the right and left fuel boost pumps had output pressure settings of 15 and 21 psi, respectively, and that the crossfeed valves had been left open, which allowed fuel to transfer from the left to the right fuel tank. Nolinor Aviation indicated that the incident airplane's left fuel boost pump had been replaced and had not been bench checked before installation. As a result, the company was unaware that the incident airplane's left fuel boost pump was operating with an output pressure setting of 21 psi. Nolinor Aviation indicated that it typically operated its Convair 580 airplanes with a fuel boost pump output pressure setting of 15 psi.

Kelowna Flightcraft, the Convair 580 type certificate holder, indicated that most operators normally set the fuel boost pumps to the same output pressure settings. However, the Safety Board is concerned that PJCB 10-21 allows Convair 580 airplanes to operate with different output pressure settings. Further, given the age of the Convair 580 fleet, current operators might not have a complete history of the airplanes, including possible changes made to the fuel boost pumps in accordance with PJCB 10-21. Although operating the Convair 580 with different fuel boost pump output pressure settings does not in itself create an unsafe operating condition, the Board notes that crossfeed valves are not monitored[58] and that the only indication that these valves are open is the switch position in the cockpit. Such operation did not factor in the accident; however, the Nolinor Aviation incident did reveal that, if an airplane operates with different fuel boost pump output pressure settings and with the crossfeed valves unintentionally left open, a large amount of fuel can transfer from one tank to another in a short period of time, possibly causing structural failure or fuel overflow.

The Safety Board concludes that fuel transfer can occur on the Convair 580 airplane if it is operated with different fuel boost pump output pressure settings and with

[58] No positive indication, such as a light, exists in the cockpit to indicate whether the crossfeed system is operating.

the fuel crossfeed valves unintentionally left open. Therefore, the Safety Board believes that the FAA should require Convair 580 operators to set the left and right fuel boost pump output pressure settings on their airplanes to the same setting.

2.7 Cockpit Voice and Image Recorder Requirements

As noted previously, whether the Convair 580's CVR electrical relay circuitry enables battery power to the CVR when the engines are in the low-speed range or shut down (which can be caused by fuel exhaustion) depends on whether the flight crew pushes in the low-rpm buttons located on the center pedestal. If the low-rpm button are pushed in when the engines are in the low-speed range or shut down, the low-rpm relays are energized, and the batteries provide power to the CVR. However, when both engines are in the low-speed range or shut down and the low-rpm buttons are not pushed in, no power is provided to the CVR.

Although electrical relay circuitry is an effective method of powering the CVR during ground operations, power to the CVR is compromised if both a.c. alternators are in the low-speed range or shut down in flight and the pilots do not push in the low-rpm buttons. Accordingly, the CVR on the accident airplane lost power when the airplane's left fuel tank was exhausted of fuel, both engines lost power, and the pilots did not push in the low-rpm buttons. The Safety Board notes that the FDR, which did not require relay circuitry to operate at lower power settings, received electrical power throughout the entire accident sequence (except for the momentary dropout of power about 0047) and operated normally until impact.

Even before this accident, the Safety Board had longstanding concerns about accidents and incidents in which critical CVR information was lost because of an electrical power interruption. As a result of its longstanding concerns about this issue and its assistance in the TSB's Swissair flight 111 accident investigation, the Board issued Safety Recommendation A-99-16 to the FAA, which stated, in part, the following:

> All airplanes required to carry both a CVR and an FDR [should be retrofitted] with a CVR that…is fitted with an independent power source…that automatically engages and provides 10 minutes of operation whenever aircraft power to the recorder ceases, either by normal shutdown or by a loss of power to the bus.

The Safety Board is disappointed that the FAA's February 28, 2005, NPRM, "Revisions to Cockpit Voice Recorder and Digital Flight Data Recorder Regulations," only proposes requiring the installation of a 10-minute independent CVR power source on newly manufactured aircraft. Therefore, in its comments on the NPRM, the Board suggested requiring the installation of a 10-minute independent CVR power source on all aircraft within 4 years of the issuance of a final rule.

As a result of its investigation of the October 19, 2004, Corporate Airlines flight 5966 accident and longstanding concerns about the loss of critical flight recorder

data, on January 24, 2006, the Safety Board reiterated Safety Recommendation A-00-30, which asked the FAA, in part, to do the following:

> Require that all aircraft operated under…14 *Code of Federal Regulations* Part 121, 125, or 135 and currently required to be equipped with a [CVR] and [DFDR] be retrofitted by January 1, 2005, with a crash-protected cockpit image recording system. The cockpit image recorder system should have a 2-hour recording duration…and be capable of recording, in color, a view of the entire cockpit including each control position and each action (such as display selections or system activations) taken by people in the cockpit.

The FAA did not address cockpit image recorders in its February 2005 NPRM. In its response to the NPRM, the Safety Board stated that it was disappointed that the FAA had not addressed image recorders in the NPRM and restated its opinion that cockpit image recorders could play a key role in accident investigations by providing critical human performance and cockpit environment information that would otherwise be unavailable.

If the accident airplane had been equipped with a 10-minute independent power source, the CVR would have recorded important information about the flight crew's actions after the loss of engine power until the airplane impacted the ground. Further, if the airplane had been equipped with a cockpit image recorder, the recorder could have provided additional critical human performance and cockpit environment information. The Safety Board concludes that the accident investigation would have benefited from the retrofit of an independent CVR power source and a cockpit image recorder. Because of its continued concerns in this area, the Safety Board reiterates Safety Recommendation A-99-16 and again urges the FAA to require the retrofit of all existing aircraft required to carry both a CVR and an FDR with a CVR that is fitted with an independent power source. Further, the Board again urges the FAA to quickly implement Safety Recommendation A-00-30.

3. Conclusions

3.1 Findings

1. The captain and first officer were properly certificated and qualified under Federal regulations.

2. No evidence indicated that flight crew fatigue was a factor in this accident, and no evidence indicated any preexisting medical or behavioral conditions that might have affected the accident flight.

3. The airplane was properly maintained in accordance with Federal regulations and approved company procedures.

4. The recovered components showed no evidence of any preexisting powerplant, system, or structural failures. No evidence indicated that any of the airplane's cargo shifted during the flight.

5. Neither the weather nor the inoperative distance measuring equipment on the Cincinnati/Northern Kentucky International Airport very high frequency omnidirectional range was a factor in this accident.

6. Sufficient fuel was on board the airplane for the flight from Memphis International Airport to Cincinnati/Northern Kentucky International Airport.

7. The captain's preflight weight and balance calculations indicated that the airplane was not within takeoff limits; therefore, he should not have allowed the airplane to take off. However, the captain's calculations were incorrect, and the airplane's weight and balance were within limits.

8. The captain did not recognize the importance of the cues provided by the first officer, and he failed to perform expected pilot-in-command duties.

9. The captain was preoccupied with the weight and balance calculations during critical portions of the flight and, as a result, he did not monitor the fuel crossfeed operations, which resulted in a fuel imbalance and unusual airplane handling characteristics.

10. The flight crew did not monitor the fuel quantity gauges or respond properly to the airplane's changing handling characteristics, and the captain did not start the in-range checklist at the appropriate altitude; as a result, the crew missed several opportunities to identify the ongoing fuel crossfeed operations and determine that the airplane's fuel was imbalanced.

11. Although fuel transfer is prohibited on the Convair 580 airplane, fuel transfer can occur during fuel crossfeed operations if the fuel tank shutoff valve for the tank not being used is left open.

12. All of the fuel from the airplane's left tank that was not used by the engines transferred into the right tank because the captain intentionally kept the right fuel tank shutoff valve open during fuel crossfeed operations, which was not in accordance with approved fuel crossfeed procedures.

13. During the airplane's descent to landing, the fuel in the left fuel tank, which was providing fuel to both engines, was exhausted because both engine-driven fuel pumps drew air from the left tank into the fuel system instead of fuel from the right tank, resulting in a dual-engine flameout.

14. Fuel transfer can occur on the Convair 580 airplane if it is operated with different fuel boost pump output pressure settings and with the fuel crossfeed valves unintentionally left open.

15. The accident investigation would have benefited from the retrofit of an independent cockpit voice recorder power source and a cockpit image recorder.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was fuel starvation resulting from the captain's decision not to follow approved fuel crossfeed procedures. Contributing to the accident were the captain's inadequate preflight planning, his subsequent distraction during the flight, and his late initiation of the in-range checklist. Further contributing to the accident was the flight crew's failure to monitor the fuel gauges and to recognize that the airplane's changing handling characteristics were caused by a fuel imbalance.

4. Recommendations

4.1 New Recommendations

As a result of its investigation of the August 13, 2004, Air Tahoma, Inc., flight 185 accident, the National Transportation Safety Board makes the following recommendations:

To the Federal Aviation Administration:

Issue a flight standards information bulletin to all principal operations inspectors of Convair 580 operators that familiarizes operators with the circumstances of the Air Tahoma flight 185 accident, including the importance of closing the fuel tank shutoff valve for the tank not being used during fuel crossfeed operations. (A-06-39)

Require Convair 580 operators to set the left and right fuel boost pump output pressure settings on their airplanes to the same setting. (A-06-40)

To Transport Canada:

Require Convair 580 operators to set the left and right fuel boost pump output pressure settings on their airplanes to the same setting. (A-06-41)

4.2 Previously Issued Recommendation Being Reiterated in This Report

The Safety Board reiterates the following recommendation to the Federal Aviation Administration:

Require retrofit after January 1, 2005, of all cockpit voice recorders (CVR) on all airplanes required to carry both a CVR and a flight data recorder with a CVR that (a) meets Technical Standard Order (TSO) C123a, (b) is capable of recording the last 2 hours of audio, and (c) is fitted with an independent power source that is located with the digital CVR and that automatically engages and provides 10 minutes of operation whenever aircraft power to the recorder ceases, either by normal shutdown or by a loss of power to the bus. (A-99-16)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

MARK V. ROSENKER
Acting Chairman

ELLEN ENGLEMAN CONNERS
Member

DEBORAH A. P. HERSMAN
Member

KATHRYN O. HIGGINS
Member

Adopted: May 2, 2006

5. Appendixes

Appendix A
Investigation and Public Hearing

Investigation

The National Transportation Safety Board was officially notified of this accident on August 13, 2004, about 0300. A full go-team was assembled in Washington, D.C. The go-team departed about 0730 and arrived on scene about 0900. The team was accompanied by Board Member Carol Carmody.[1]

The following investigative groups were formed: Operations, Aircraft Structures, Aircraft Systems, Aircraft Powerplants, Aircraft Maintenance Records, Meteorology, Air Traffic Control, Aircraft Performance, Cockpit Voice Recorder, and Flight Data Recorder. A Human Factors specialist was also assigned to review and analyze the flight crew's performance during the flight.

Parties to the investigation were the Federal Aviation Administration; Air Tahoma, Inc.; and Rolls-Royce. An accredited representative from the Transportation Safety Board of Canada (TSB) and the TSB's technical advisor from Kelowna Flightcraft Ltd. also assisted in the investigation.

Public Hearing

No public hearing was held for this accident.

[1] Ms. Carmody is no longer with the Safety Board.

Appendix B
Cockpit Voice Recorder Transcript

The following is the transcript of the Honeywell Sundstrand V557 model cockpit voice recorder, serial number 2372, installed on Air Tahoma flight 185, a Convair 580, which crashed while on approach for landing at Cincinnati/Northern Kentucky International Airport, Covington, Kentucky, on August 13, 2004.

Transcript of a Honeywell Sundstrand V557 tape cockpit voice recorder, serial number 2372, installed on an Air Tahoma Convair 580, N586P Flight 185, which crashed one mile from the Cincinnati Northern Kentucky International Airport in Florence, Kentucky.

LEGEND

CAM	Cockpit area microphone voice or sound source
HOT	Crew station voice or sound source
RDO	Radio communications transmitted from N586P, Air Tahoma Flight 185
MCTR	Radio transmission from Memphis Center controller
CTR1	Radio transmission from first Indianapolis Center controller
CTR2	Radio transmission from second Indianapolis Center controller
APR	Radio transmission from Cincinnati Approach controller
TWR	Radio transmission from Cincinnati Northern Kentucky tower controller
RAMP	Radio transmission from DHL ramp control at Cincinnati Northern Kentucky
-1	Voice identified as the Captain
-2	Voice identified as the First Officer
-?	Voice unidentified
*	Unintelligible word
#	Expletive
@	Non-pertinent word
( )	Questionable insertion
[ ]	Editorial insertion
...	Pause or interruption

Note 1: Times are expressed in eastern daylight time (EDT).

Note 2: Generally, only radio transmissions to and from the accident aircraft were transcribed.

Note 3: Words shown with excess vowels, letters, or drawn out syllables are a phonetic representation of the words as spoken.

Note 4: A non-pertinent word or phrase, where noted, refers to a name or a word not directly related to the operation, control or condition of the aircraft.

INTRA-COCKPIT COMMUNICATION		1 of 25	AIRCRAFT-TO-GROUND COMMUNICATION	
Time (EDT) SOURCE	CONTENT		Time (EDT) SOURCE	CONTENT
0016:03 **START OF RECORDING** **START OF TRANSCRIPT**				
0017:49 **HOT-1**	just gonna balance out the fuel here.			
0017:51 **HOT-2**	okay.			
			0018:00 **MCTR**	Tahoma four eighty five contact Indy center one two one point one seven.
			0018:04 **RDO-1**	one two one one seven. one eighty five.
			0018:26 **RDO-1**	center Tahoma one eighty five with you fifteen thousand.
			0019:23 **RDO-1**	center Tahoma one eighty five with you fifteen thousand.
			0019:27 **CTR1**	Tahoma one eighty five Indy center Louisville altimeter three zero zero eight.
			0019:31 **RDO-1**	zero eight.

INTRA-COCKPIT COMMUNICATION		2 of 25	AIRCRAFT-TO-GROUND COMMUNICATION	
Time (EDT) SOURCE	CONTENT		Time (EDT) SOURCE	CONTENT
0019:33 HOT-1	Indy center three zero zero eight.			
0019:34 HOT-2	copy that.			
0026:30 HOT-1	all this time I was ah working out...			
0026:32 HOT-2	yeah?			
0026:32 HOT-1	... couldn't figure out why on the landing I was out and I was okay on the takeoff...			
0026:36 HOT-2	yeah?			
0026:36 HOT-1	... and it was my ah my chicken scratch. the the...			
0026:40 HOT-2	uh.			
0026:40 HOT-1	the momentum is one six six seven and I thought my chicken scratch I put one zero six seven and I couldn't work it...			

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
Time (EDT) SOURCE	CONTENT	Time (EDT) SOURCE	CONTENT
0026:48 **HOT-2**	ohh.		
0026:48 **HOT-1**	... it was my my own doing.		
0026:50 **HOT-2**	oh #.		
0026:50 **HOT-1**	so I had it all along we were okay all along.		
0026:53 **HOT-2**	oh is that right? oh man *. [sound of laughing]		
0026:56 **HOT-1**	[sound of laughing]		
0026:58 **HOT-1**	it bothered me that you know...		
0027:00 **HOT-2**	right.		
0027:00 **HOT-1**	...it does make sense...		
0027:01 **HOT-2**	right.		

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
Time (EDT) SOURCE	CONTENT	Time (EDT) SOURCE	CONTENT
0027:02 HOT-1	that on landing y-y-you burn that fuel off the wing that's forward right?		
0027:06 HOT-2	right.		
0027:06 HOT-1	so you're gonna be more tail heavy.		
0027:07 HOT-2	right.		
0027:08 HOT-1	so.		
		0028:10 CTR1	Tahoma one eighty five the winds are kinda weird today they're * suggest ten left to Cincinnati.
		0028:16 RDO-1	* say again Tahoma one eighty five?
		0028:19 CTR1	ah I suggest ten degrees left there Tahoma one eighty five for Cincinnati when able.

INTRA-COCKPIT COMMUNICATION		5 of 25	AIRCRAFT-TO-GROUND COMMUNICATION	
Time (EDT) SOURCE	CONTENT		Time (EDT) SOURCE	CONTENT
			0028:22 RDO-1	okay ten degrees left and ah Cincinnati when able one eighty five thank you.
0028:27 HOT-2	already had it.			
0028:29 HOT-2	I had it right on the money.			
0028:39 HOT-2	the winds are kinda weird.			
			0028:40 CTR1	Tahoma one eighty five contact Indy center one two four point seven seven.
			0028:44 RDO-1	one twenty four seventy seven good day.
			0028:46 CTR1	good day.
0028:52 HOT-2	* follow the G-P-S * should be okay right?			
0028:54 HOT-1	yeah.			

INTRA-COCKPIT COMMUNICATION		6 of 25	AIRCRAFT-TO-GROUND COMMUNICATION	
Time (EDT) SOURCE	CONTENT		Time (EDT) SOURCE	CONTENT
0028:55 HOT-2	* cleared direct now # I was on the right # heading.			
			0029:00 RDO-1	Indy center ah Tahoma one eighty five with you fifteen thousand.
			0029:06 CTR2	Tahoma one eighty five Indy center roger the Louisville altimeter three zero zero five.
			0029:11 RDO-1	zero five.
0029:18 HOT-2	wanna give them a call @ we're about.			
0029:21 HOT-1	oh okay ah.			
0029:22 HOT-2	we're about twenty minutes out.			
0029:23 HOT-1	twenty nine oh...			
0029:23 HOT-2	I got it.			

INTRA-COCKPIT COMMUNICATION		7 of 25	AIRCRAFT-TO-GROUND COMMUNICATION	
Time (EDT) SOURCE	CONTENT		Time (EDT) SOURCE	CONTENT
0029:24 **HOT-1**	...you got it.			
0029:24 **HOT-2**	I got it **.			
0029:25 **HOT-1**	okay you got guard one I'll give them a talk.			
0029:27 **HOT-2**	sure.			
0029:31 **HOT-1**	that's ramp tower isn't it?			
0029:32 **HOT-2**	yeah.			
			0029:35 **RDO-1**	ah ramp tower Tahoma one eighty five.
			0029:38 **RAMP**	five good morning go.
			0029:39 **RDO-1**	yeah twenty minutes E-T-A.
			0029:54 **RDO-1**	ah you copy ah from one eighty five?

INTRA-COCKPIT COMMUNICATION		8 of 25	AIRCRAFT-TO-GROUND COMMUNICATION	
Time (EDT) **SOURCE**	**CONTENT**		Time (EDT) **SOURCE**	**CONTENT**
			0029:58 **RAMP**	five south ramp *.
			0029:59 **RDO-1**	* okay.
0030:02 **HOT-1**	south ramp.			
0030:05 **HOT-2**	get outa here... [sound of laughing]			
0030:06 **HOT-1**	yeah yeah.			
0030:07 **HOT-2**	really? [sound of laughing]			
0030:09 **HOT-2**	you go ahead and get the ATIS and stuff like that.			
0030:11 **HOT-1**	yeah.			
0030:19 **HOT-1**	okay *.			

INTRA-COCKPIT COMMUNICATION		9 of 25	AIRCRAFT-TO-GROUND COMMUNICATION	
Time (EDT) SOURCE	CONTENT		Time (EDT) SOURCE	CONTENT
			0030:20 ATIS	[recorded on the Captain's channel] notices to airman runway three six right D-M-E out of service...
0030:23 HOT-1	you're guarding one still right?			
0030:24 HOT-2	okay yeah I got it.			
0030:25 HOT-1	so I'll get the ATIS.			
0030:26 HOT-2	all right.			
			0030:27 ATIS	runway niner I-L-S out of service. sequence flashers out of service. runway niner threshold displaced twelve hundred feet. runway two seven I-L-S out of service. runway two seven ** two thousand seven hundred feet closed. eighty eight hundred feet available for departure...
0030:40 HOT-2	*** # **... weird.			

INTRA-COCKPIT COMMUNICATION		10 of 25	AIRCRAFT-TO-GROUND COMMUNICATION	
Time (EDT) SOURCE	CONTENT		Time (EDT) SOURCE	CONTENT
			0030:41 ATIS	...taxiway Kilo closed west of one eight right. * VOR-TAC out of service. bird activity vicinity airport. advise on initial contact you have information Bravo. Cincinnati Northern Kentucky International Airport arrival information Bravo. zero three five one Zulu. wind three four zero at five. visibility one zero. ceiling eight thousand overcast. temperature one five dew point niner. altimeter three zero zero four. simultaneous approaches in use. expect visual approach to runway three six right three six left. notices to airman runway three six right D-M-E out of service. runway niner I-L-S out of service. sequence flashers out of service. runway niner threshold displaced twelve hundred feet. runway two seven I-L-S out of service. runway two seven ** two thousand seven hundred feet.
0031:45 HOT-1	okay.			
0031:46 HOT-2	sure.			
0031:46 HOT-1	back with you on number one.			
0031:47 HOT-2	all right.			
0031:48 HOT-1	and it's ah Bravo. three forty at five knots. visibility ten miles. ceiling eight thousand overcast. temperature fifteen. dew point nine. three zero zero four.			

INTRA-COCKPIT COMMUNICATION		11 of 25	AIRCRAFT-TO-GROUND COMMUNICATION	
Time (EDT) SOURCE	CONTENT		Time (EDT) SOURCE	CONTENT
0031:59 HOT-2	all right set on the right.			
0032:00 HOT-1	and it's a visual for thirty six right the D-M-E is inoperative on thirty. six right			
0032:04 HOT-2	okay.			
0032:05 HOT-1	okay *.			
0032:06 HOT-2	thank you sir.			
			0032:15 CTR2	Tahoma one eighty five cross three five miles south of Cincinnati at maintain one one thousand.
			0032:18 RDO-1	thirty five at ah one one thousand. one eighty five.
0032:27 HOT-2	all right **.			
0032:31 HOT-1	okay just let me finish this off and ah I'm happy.			

INTRA-COCKPIT COMMUNICATION		12 of 25	AIRCRAFT-TO-GROUND COMMUNICATION	
Time (EDT) SOURCE	CONTENT		Time (EDT) SOURCE	CONTENT
0033:11 CAM	[sound of clacking, similar to maximum airspeed warning, continues until 0034:35]			
0033:13 HOT-2	oh yeah. I knew you were coming.			
0034:20 HOT-1	okay back with you here and I'm *.			
0034:31 HOT-1	hey what's that noise.			
0034:32 HOT-2	[sound of laughing] hey.			
0034:44 HOT-1	one to go.			
			0036:04 CTR2	[Air France four thirty nine radio transmission]
0036:14 HOT-1	en France.			
0036:17 HOT-2	français.			

INTRA-COCKPIT COMMUNICATION		13 of 25	AIRCRAFT-TO-GROUND COMMUNICATION	
Time (EDT) SOURCE	CONTENT		Time (EDT) SOURCE	CONTENT
			0036:44 **CTR2**	Tahoma one eighty five contact Cincinnati approach one two six point six five good night.
			0036:49 **RDO-1**	one two six six five ah good night one eighty five.
			0037:08 **RDO-1**	Cincinnati approach * Tahoma one eighty five with you one one thousand.
			0037:13 **APR**	Tahoma one eighty five Cincinnati approach runway three six right.
			0037:17 **RDO-1**	thirty six right.
0037:21 **HOT-1**	he knows we're here.			
0037:25 **HOT-1**	I'll back you up on the ah I-L-S.			
0037:27 **HOT-2**	all right copy that.			
0037:29 **HOT-2**	that'll be a visual three six right.			

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
Time (EDT) SOURCE	CONTENT	Time (EDT) SOURCE	CONTENT
0037:34 HOT-1	thirty six right ten thirty five.		
0037:36 HOT-2	let's see v ref's one fifty four seventeen twenty eight is one thirty one oh six. B-SEC is one three six.		
0037:53 HOT-1	ten thirty five once twice.		
0038:22 HOT-2	huh. something's *. something messed up with this thing. ***.		
0038:26 HOT-1	does he have us on a heading or.		
0038:29 HOT-2	ah no I was on a V-O-R.		
0038:30 HOT-1	oh okay. yeah I never touched nothing. you're still on blue light.		
0038:34 HOT-2	oh okay yeah oh I see yeah I was looking at it over here.		
0038:37 HOT-1	yep. you're still direct to Cincinnati right?		

INTRA-COCKPIT COMMUNICATION		15 of 25	AIRCRAFT-TO-GROUND COMMUNICATION	
Time (EDT) SOURCE	CONTENT		Time (EDT) SOURCE	CONTENT
0038:41 HOT-2	yes.			
0038:41 HOT-1	okay.			
0038:51 HOT-1	* D-M-E's working on this ah... oh no no no.			
			0038:56 APR	Tahoma one eight five maintain seven thousand.
			0038:58 RDO-1	maintain seven thousand one eighty five.
0039:01 HOT-1	down we go. down we go.			
0039:07 HOT-2	why is this thing **.			
0039:07 HOT-1	seven thousand in the box.			
0039:10 HOT-2	all right.			

INTRA-COCKPIT COMMUNICATION		16 of 25	AIRCRAFT-TO-GROUND COMMUNICATION	
Time (EDT) SOURCE	CONTENT		Time (EDT) SOURCE	CONTENT
			0039:18 **APR**	Tahoma one eighty five ah turn ten degrees right vectors for sequence.
			0039:22 **RDO-1**	ah ten degrees right ah one eighty five.
0041:00 **HOT-1**	yep.			
0041:09 **HOT-1**	keep it coming down.			
0041:13 **HOT-2**	oh yeah she's coming.			
0041:15 **HOT-1**	yee haw.			
0041:21 **HOT-2**	I'm trying to mess with this ah yoke feels funny.			
0041:26 **HOT-1**	say again?			
0041:27 **HOT-2**	I said it * feels like I need a lot of force. it's pushing to the right for some reason I don't know why. I'm trying to. I don't know what's going on…			

INTRA-COCKPIT COMMUNICATION		17 of 25	AIRCRAFT-TO-GROUND COMMUNICATION	
Time (EDT) SOURCE	CONTENT		Time (EDT) SOURCE	CONTENT
			0041:29 **APR**	Tahoma one eighty five fly heading zero niner zero descend and maintain ah four thousand.
0041:29 **HOT-2**	...feels like I need a lot of force. it.			
			0041:36 **APR**	Tahoma one eighty five fly heading zero nine zero maintain four thousand.
			0041:39 **RDO-1**	zero nine zero four thousand Tahoma one eighty five.
0041:43 **HOT-2**	**.			
0041:45 **HOT-1**	zero nine zero.			
0041:49 **HOT-1**	four thousand.			
0042:02 **HOT-2**	it's like you need a lot of force to go to the right for some # reason I don't know **.			
0042:08 **HOT-1**	anyway's four's in the box. zero nine zero.			

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
Time (EDT) SOURCE	CONTENT	Time (EDT) SOURCE	CONTENT
0042:12 **HOT-2**	huh. oh well.		
0042:17 **HOT-2**	I thought that was for the rudder. I thought you needed rudder **.		
		0042:24 **APR**	Tahoma one eighty five maintain four thousand.
		0042:26 **RDO-1**	maintain four thousand one eighty five.
0042:32 **HOT-2**	***.		
0042:46 **CAM**	[sound of buzz, similar to landing gear warning horn]		
0042:49 **HOT-?**	sorry.		
0043:06 **HOT-1**	he's packed tonight so we're gonna go bang bang bang.		
0043:11 **HOT-2**	got it oh yeah.		

INTRA-COCKPIT COMMUNICATION		19 of 25	AIRCRAFT-TO-GROUND COMMUNICATION	
Time (EDT) SOURCE	CONTENT		Time (EDT) SOURCE	CONTENT
0043:15 HOT-1	ehhhhh.			
0043:24 HOT-2	we're down to four right?			
0043:25 HOT-1	yep. down to four thousand. you got your strobes on?			
			0043:28 APR	Tahoma one eighty five maintain three thousand fly heading zero four zero join the three six right localizer.
			0043:33 RDO-1	zero four zero down to three thousand join the localizer thirty six right one eight five.
0043:44 HOT-1	yeah just so 'cause I don't have the landing lights ah.			
			0043:46 APR	Tahoma one eighty five report field.
			0043:48 RDO-1	one eighty five.
0043:50 HOT-2	eh we got the field in sight.			

INTRA-COCKPIT COMMUNICATION		20 of 25	AIRCRAFT-TO-GROUND COMMUNICATION	
Time (EDT) SOURCE	CONTENT		Time (EDT) SOURCE	CONTENT
0043:52 HOT-1	field in sight.			
			0043:53 RDO-1	field in sight one eighty five.
			0043:54 APR	*homa one eighty five cleared visual approach three six right keep your speed up.
			0043:56 RDO-1	visual approach thirty six right keep the speed up one eight five.
0044:08 HOT-1	and that was down to three thousand.			
0044:10 HOT-2	yes.			
0044:12 HOT-2	three six right correct?			
0044:12 HOT-1	thirty six right.			
0044:14 HOT-2	copy that.			

INTRA-COCKPIT COMMUNICATION		21 of 25	AIRCRAFT-TO-GROUND COMMUNICATION	
Time (EDT) SOURCE	CONTENT		Time (EDT) SOURCE	CONTENT
0044:16 HOT-2	what in the world is going on with this plane? sucker is acting so funny.			
0044:21 HOT-1	well we'll do a full control check on the ground then ah.			
0044:32 HOT-1	annnd.			
			0044:40 APR	Tahoma one eighty five did I clear you for the visual?
			0044:42 RDO-1	affirmative.
			0044:43 APR	okay and ah keep your speed up contact tower one one eight point three.
			0044:47 RDO-1	eighteen three one eighty five.
0044:50 HOT-2	keep your speed up? # we're going two hundred fifty knots.			
0044:54 HOT-1	yeah. point it down at three thousand as quick as you can then we'll start ah I'll go to the tower here.			

INTRA-COCKPIT COMMUNICATION		22 of 25	AIRCRAFT-TO-GROUND COMMUNICATION	
Time (EDT) SOURCE	CONTENT		Time (EDT) SOURCE	CONTENT
			0045:11 **RDO-1**	ah Cincinnati tower Tahoma one eighty five with you visual thirty six right.
			0045:16 **TWR**	** five Cincinnati tower good evening traffic seven two seven four mile final wind calm runway three six right cleared to land.
			0045:22 **RDO-1**	and cleared to land thirty six right ah one eighty five.
0045:27 **HOT-1**	I got that traffic there.			
0045:31 **HOT-1**	we got the runway.			
0045:33 **HOT-2**	yes. runway's in sight.			
0045:34 **HOT-1**	and I'll give you the in range.			
0045:36 **HOT-2**	okay yeah in range check.			
0045:37 **HOT-1**	in range check cabin pressure.			

INTRA-COCKPIT COMMUNICATION		23 of 25	AIRCRAFT-TO-GROUND COMMUNICATION	
Time (EDT) SOURCE	CONTENT		Time (EDT) SOURCE	CONTENT
0045:39 HOT-2	set.			
0045:41 HOT-1	bypass is down. hydraulic pressure.			
0045:46 HOT-1	quantity checks.			
0045:48 HOT-1	AC pump is on. green light. fuel panel. boost pumps on.			
0046:07 HOT-2	man I'm telling you what is wrong with this plane? it is really funny.			
0046:18 HOT-2	I got something's all messed up here.			
0046:20 HOT-1	yeah.			
0046:21 HOT-2	can you feel it? it's like swinging back and forth.			
0046:24 HOT-1	yeah we've got an inbalance on this # cross feed I left open.			

INTRA-COCKPIT COMMUNICATION			AIRCRAFT-TO-GROUND COMMUNICATION	
Time (EDT) SOURCE	CONTENT		Time (EDT) SOURCE	CONTENT
0046:28 **HOT-2**	oh is that what it is?			
0046:29 **HOT-1**	yeah.			
0046:29 **HOT-2**	oh # I see.			
0046:30 **HOT-1**	yeah. #.			
0046:32 **HOT-2**	oh I see what it is.			
0046:33 **HOT-1**	yeah.			
0046:35 **HOT-2**	we're gonna flame out if we don't aren't we?			
0046:37 **HOT-1**	I got the cross feed open. just keep power on.			
0046:45 **CAM**	[sound similar to decreasing engine RPM]			
0046:47 **HOT-2**	# we're losing power.			

INTRA-COCKPIT COMMUNICATION		AIRCRAFT-TO-GROUND COMMUNICATION	
Time (EDT) SOURCE	CONTENT	Time (EDT) SOURCE	CONTENT
0046:49 HOT-1	on number. okay.		
0046:52 HOT-2	we've lost both of them. did we?		
0046:53 HOT-1	nope.		
0046:55 **END OF TRANSCRIPT** **END OF RECORDING**			

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