Aviation Investigation Final Report

Location:	San Angelo, Texas	**Incident Number:**	FTW00IA228
Date & Time:	August 12, 2000, 13:03 Local	**Registration:**	N16718
Aircraft:	Embraer EMB-120ER	**Aircraft Damage:**	None
Defining Event:		**Injuries:**	1 Minor, 22 None
Flight Conducted Under:	Part 121: Air carrier - Scheduled		

Analysis

The airplane was descending through 14,500 feet when an uncommanded disconnect of the autopilot occurred, and the airplane "abruptly" pitched up from 5 degrees nose down to 15 degrees nose up (pitch reversion). Simultaneously, the captain and first officer applied forward pressure on their control columns to regain control of the airplane. The airplane was re-established in a descent and the flight crew found that the airplane was controllable in the landing configuration. Subsequently, the flight landed without further incident. Post incident examination of the airplane revealed that the right elevator trim control wheel was improperly installed. The installation allowed the autopilot trim servo to request nose down trim until the trim tab actuators had reached their physical limits. The autopilot trim servo continued to request nose down trim, loading the elevator trim system cables, until the autopilot disconnected. During the examination, it was also noted that the trim tab deflections and cable tensions did not meet manufacturer specifications. Review of maintenance records revealed two instances when the elevator pitch trim system underwent maintenance. On April 14, 1998, the right side elevator trim control wheel was removed and reinstalled "while aligning stop arm into wheel." Continental Express reported that the trim tabs were adjusted during the maintenance. On August 11, 2000, the following maintenance write-up was recorded in the aircraft flight log: "Elev trim will not go full forward, stops at two units." The flight log indicated that the following corrective action was taken; "Lubed trim wheel for elev trim." Continental Express reported that the trim wheel was not removed during this corrective action.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this incident to be: the improper installation of the right elevator trim control wheel by company mechanics, which resulted in an elevator trim malfunction.

Findings

Occurrence #1: AIRFRAME/COMPONENT/SYSTEM FAILURE/MALFUNCTION
Phase of Operation: DESCENT - NORMAL

Findings
1. FLT CONTROL SYST,ELEVATOR TRIM/TAB CONTROL
2. (C) MAINTENANCE,INSTALLATION - IMPROPER - COMPANY MAINTENANCE PERSONNEL
3. (C) FLT CONTROL SYST,ELEVATOR TRIM/TAB CONTROL - MALFUNCTION
4. PRECAUTIONARY LANDING - PERFORMED - PILOT IN COMMAND

Factual Information

HISTORY OF FLIGHT

On August 12, 2000, at 1303 central daylight time, an Embraer EMB-120ER twin turboprop airplane, N16718, operating as Jetlink flight 2931, experienced an uncommanded disconnect of the autopilot while descending, and proceeded to land without further incident at the San Angelo Regional Airport (SJT), San Angelo, Texas. The airplane was registered to the Chase Manhattan Bank and Trust Co., of San Francisco, California, and operated by Continental Express Airlines Inc., of Houston, Texas. The airline transport rated captain, airline transport rated first officer, and 20 passengers were not injured; the flight attendant sustained minor injuries. Visual meteorological conditions prevailed, and an instrument flight rules (IFR) flight plan was filed for the 14 Code of Federal Regulations Part 121 scheduled domestic passenger flight. The flight originated from the George Bush Intercontinental Airport, Houston (IAH), Texas, at 1145, and was destined for San Angelo, Texas.

According to the captain and first officer, the captain was the flying pilot. The flight was cleared by the Houston Air Route Traffic Control Center (HOU ARTCC) to descend from flight level 200 to 6,000 feet. The captain established the airplane in a 1,500 foot per minute descent, at 260 knots, with the autopilot engaged in the descent mode. The airplane was descending through 14,500 feet when the airplane experienced an uncommanded disconnect of the autopilot, and the airplane "abruptly" pitched up from five degrees nose down to 15 degrees nose up (pitch reversion). Simultaneously, the captain and first officer applied forward pressure on their control columns to regain control of the airplane. The captain stated that he observed the pitch trim in the "full nose down position," immediately following the event. The first officer reported that after the event, the captain stated that "he could not trim the aircraft and he needed more nose down than he had available."

The airplane was re-established in a descent; however, the captain had to maintain constant forward pressure on the control column to maintain the descent. The captain then retarded the throttle and slowed the airplane to 200 knots, and forward pressure on the control was no longer needed. The flight crew referenced the quick reference handbook (QRH), but did not find any section that was applicable to the event experienced. They decided to descend to 10,000 feet and execute a controllability check. The captain reported that with the airplane in the landing configuration he was able to control the airplane without applying abnormal force to the control column and with normal use of pitch trim. The first officer contacted the flight attendant following the event and she reported that her right leg had been injured; however, none of the passengers had been injured. The flight crew then declared an emergency and the airplane landed in San Angelo without further incident. Upon arrival in San Angelo the flight attendant was transported to a hospital, treated, and released the same day.

The flight attendant reported that, prior to the pitch event the first officer had made an announcement to the passengers indicating that the airplane had begun its descent for landing, and he illuminated the fasten seat belt sign. She stated that she was in the rear galley of the airplane, preparing for landing, when "the back of the plane dropped and [she] flew into the air." Subsequently, she landed on the galley floor, on her right ankle and leg.

PERSONNEL INFORMATION

The captain was hired by Continental Express on June 11, 1998. On May 8, 2000, he was issued an airline transport pilot certificate, and satisfactorily completed his most recent flight proficiency check. He held type ratings in the Embraer EMB-120 and the McDonnell Douglas DC-10. According to information provided by Continental Express, the captain had accumulated a total of 5,500 flight hours, of which 120 hours were in the EMB-120. Additionally, he underwent his most recent FAA medical examination, and obtained a first class medical certificate with no limitations, on July 1, 2000.

The first officer was hired by Continental Express on March 8, 1999, and satisfactorily completed his most recent flight proficiency check on May 11, 2000. He held an airline transport pilot certificate that was issued on July 5, 1996. He held type ratings in the Boeing 707 and Boeing 720. According to information provided by Continental Express, the first officer had accumulated a total of 3,811 flight hours, of which 815 hours were in the Embraer EMB-120. Additionally, he underwent his most recent FAA medical examination, and obtained a first class medical certificate with no limitations, on February 1, 2000.

The flight attendant underwent her initial operating experience (IOE) check on July 8, 2000, and was hired by Continental Express on July 17, 2000.

AIRCRAFT INFORMATION

The 1989 Embraer EMB-120ER airplane (serial number 120136) was delivered new to Continental Express. It was configured with 30 passenger seats, three crew seats, and was powered by two Pratt & Whitney PW-118 turboprop engines. At the time of the event, the airplane had accumulated a total of 22,727.4 hours.

The elevator trim tab system is a subsystem of the elevator system that enables the pilot, co-pilot, or the autopilot to adjust the pitch of the airplane. When the autopilot is in use, an autopilot trim servo automatically adjusts the elevator trim. The elevator trim may also be activated by the pilot or co-pilot via the electric switches mounted on the flight control columns, or via one of the elevator trim wheels located on either side of the central cockpit pedestal structure. The plastic trim control wheels are interconnected via a shaft. The inner side of the right trim control wheel is fitted with a spiral track, which is referred to as the cursor gearing. When the right trim wheel is inserted onto the interconnecting shaft, the physical backstop of the cursor gearing meets with the tip of the movable backstop. The movable backstop is mounted to the central cockpit pedestal. When the trim is adjusted, the tip of the

movable backstop rides along the cursor gearing. The elevator trim wheels are connected to the elevator trim tab surfaces through a series of cables, chains, pulleys, sprockets, bell cranks, and rods. The elevator trim pitch down limit is set when the control wheel on the right side of the central cockpit pedestal (co-pilot's side) is installed.

The Embraer maintenance manual provides procedures for the installation of the elevator trim control wheels (MM 27-32-03). The left trim wheel is first positioned on the interconnecting shaft. The right trim wheel is then positioned on the interconnecting shaft so that the tip of the movable backstop fits into the cursor gearing. The tip of the movable backstop must be inserted so that it is flush with the pitch down physical backstop of the cursor gearing; simultaneously, the pitch trim scale on the pedestal must indicate the pitch down limit on the cockpit elevator trim scale. The pitch down limit may be two or three units, depending on modifications to the airplane. Aircraft 120136 was modified so that the scale's pitch down limit was three units.

According to Embraer, if the tip of the movable backstop is inserted into the cursor gearing correctly (so that the physical backstop limits the travel of the trim wheel at two or three units on the elevator trim scale), and the airplane is trimmed by the autopilot trim servo to the two or three unit limit, the autopilot will disconnect and a pitch reversion will not occur. However, if the tip of the movable backstop is not inserted into the cursor gearing correctly (so that the physical backstop will not be reached at the two or three unit limit on the elevator trim scale), the autopilot may request nose down trim until the trim tab actuators reach their physical limits. When the trim tab actuators reach their limits the autopilot may continue to request nose down trim, which will result in loading of the cables in the elevator trim tab system. When the autopilot trim servo is unable to move the cables, the autopilot will disconnect, which may result in spring back of the elevator trim tabs and pitch reversion.

On September 13, 1997, Embraer issued Alert Service Bulletin (ASB) 120-27-A081. The ASB alerted operators that two airplanes had experienced "uncommanded reversion of the elevator pitch trim tab, during the descent phase with the Auto Pilot descent mode engaged." It was reported that one airplane's movable backstop tip, which should be positioned at the physical back stop within the cursor gearing during installation, was not at its correct position. The second airplane's movable backstop tip was completely out of the cursor gearing. The ASB recommended that operators inspect their airplanes to ensure that the right trim wheel of the elevator pitch trim system was installed correctly, and also recommended the installation of a guide to maintain the movable backstop in the cursor gearing. On January 13, 1998, the FAA issued Airworthiness Directive (AD) 97-26-22, which made the actions stated in Embraer's ASB mandatory.

The airplane maintenance records were reviewed. On April 14, 1998, the following discrepancy was recorded on a routine/nonroutine work card (Continental Express Form M602): "Elevator trim wheel does not stop at its limits (at markings)." The work card indicated the following corrective action; "Removed rt. side trim wheel and reinstalled while aligning stop arm into wheel, EMB. mm. ref. 27-32-03, ops chkd travel to stops-chkd ok." Continental Express

reported that the trim tabs were adjusted during the maintenance. On August 11, 2000, (one day prior to the event) the following maintenance write-up was recorded in the aircraft flight log: "Elev trim will not go full forward, stops at two units." The flight log indicated that the following corrective action was taken; "Lubed trim wheel for elev trim." Continental Express reported that the trim wheel was not removed during this corrective action. No other maintenance documents pertaining to the elevator trim system were noted.

FLIGHT RECORDERS

The cockpit voice recorder (CVR), Allied Signal part number 93A-100-83, was removed from the airplane and was examined at the NTSB Vehicle Recorders Laboratory in Washington, D.C. The communications during the event were captured on the recorder. The communications were consistent with the reports of the captain and first officer, and the CVR was returned to Continental Express. A transcript was not prepared.

The digital flight data recorder (DFDR), Allied Signal part number 980-4100-FXUS, was removed from the airplane and examined at the NTSB Vehicles Recorder Laboratory in Washington D.C. The following parameters were extracted and plotted on a line graph: pitch, pitch trim, vertical acceleration, longitudinal acceleration, lateral acceleration, airspeed, and pressure altitude coarse.

According to the DFDR data, during the 8 second period prior to the disconnect of the autopilot, the airplane was in a steady descent and had descended 220 feet. The pitch values remained between -4.83 degrees and -5.10 degrees, and the pitch trim values remained between -4.94 degrees and -4.92 degrees. The following pitch values were sequentially recorded during the one second period prior to the event: -4.92, -5.01, -5.01, -5.10. The following pitch trim values were sequentially recorded during the one second prior to the event: -4.93, -4.93, -4.93. Following the disconnect of the autopilot, the pitch value changed from -5.10 to +2.20 degrees, and the pitch trim value changed from -4.93 to -2.09 degrees. The airspeed was recorded at 261.4 knots and the pressure altitude coarse was recorded at 13,007 feet at the time of the event. Additionally, the maximum vertical acceleration during the event was 2.669 g's.

TESTS AND RESEARCH

The airplane was first examined at SJT by an FAA inspector and personnel from Continental Express Airlines. While on the ground, the autopilot was engaged in the descent mode and nose down elevator trim was requested. The elevator trim continued to run nose down, past the three unit limit on the cockpit scale, and subsequently, the autopilot disconnected. When the autopilot disconnected, the right trim wheel "spool[ed] backward from 3 units nose down to approximately 1.5 units nose down." There was movement of the trim tabs during the spool back (reversion).

The airplane was issued a ferry permit by the FAA and was flown back to the Continental Express Maintenance Facility at IAH. The airplane was then examined by the NTSB and

Continental Express. Examination of the right trim wheel revealed that the movable backstop was within the cursor gearing; however, it was not installed in the correct position. The trim tab rigging was then checked according to the Embraer Maintenance Manual (MM 27-32-00). The trim tab deflections were measured and the left tab was 2.14 degrees and the right tab was 0.7 degrees. According to Embraer, both trim tab deflections should have measured 5.7 degrees. The elevator trim cable tensions were measured; the left cable was 15 pounds and the right cable was 41 pounds.

ADDITIONAL INFORMATION

On August 16, 2000, four days after the incident, Continental Express initiated a one-time inspection program (Engineering Authorization 2730-01037) for each of its EMB-120 airplanes. The inspection checked for proper rigging of the elevator pitch trim control wheel, pitch trim cables, and proper deflections of the elevator trim tabs. In conjunction with the inspection program Continental Express imposed temporary flight restrictions (Flight Information Letter 00-50) to reduce the risk of a pitch reversion. The restrictions were removed when the inspections were completed.

On September 1, 2000, Embraer issued Service Bulletin (SB) 120-27-0081. The SB required that each operator of an EMB-120 series airplane accomplish a one-time inspection, to visually inspect the movable backstop of the elevator pitch trim command system, ensuring that it was installed correctly. On October 13, 2000, the FAA issued AD 2000-19-10, which made the actions stated in the SB mandatory, within 100 flight hours. On August 2, 2001, Embraer issued SB 120-25-0256 which suggested that operators add a placard to the outside of the right trim control wheel to alert maintenance personnel of the correct procedures when installing/assembling the right trim control wheel. The placard states, "CAUTION RH TRIM ELEVATOR TRIM WHEEL-MM 27-32-03 MUST BE FOLLOWED FOR INSTALLATION."

Pilot Information

Certificate:	Airline transport	**Age:**	37,Male
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	No
Medical Certification:	Class 1 Valid Medical--no waivers/lim.	**Last FAA Medical Exam:**	July 1, 2000
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	May 8, 2000
Flight Time:	5500 hours (Total, all aircraft), 120 hours (Total, this make and model), 2500 hours (Pilot In Command, all aircraft), 200 hours (Last 90 days, all aircraft), 55 hours (Last 30 days, all aircraft), 5 hours (Last 24 hours, all aircraft)		

Co-pilot Information

Certificate:	Airline transport	**Age:**	35,Male
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	None	**Restraint Used:**	
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	No
Medical Certification:	Class 1 Valid Medical--no waivers/lim.	**Last FAA Medical Exam:**	February 1, 2000
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	May 11, 2000
Flight Time:	3811 hours (Total, all aircraft), 815 hours (Total, this make and model), 2340 hours (Pilot In Command, all aircraft), 185 hours (Last 90 days, all aircraft), 61 hours (Last 30 days, all aircraft), 5 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Embraer	**Registration:**	N16718
Model/Series:	EMB-120ER EMB-120ER	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Transport	**Serial Number:**	120136
Landing Gear Type:	Retractable - Tricycle	**Seats:**	33
Date/Type of Last Inspection:	Continuous airworthiness	**Certified Max Gross Wt.:**	26609 lbs
Time Since Last Inspection:		**Engines:**	2 Turbo prop
Airframe Total Time:	22727.4 Hrs	**Engine Manufacturer:**	P&W
ELT:		**Engine Model/Series:**	PW-118
Registered Owner:	Chase Manhattan Bank and Trust Company	**Rated Power:**	2000 Horsepower
Operator:	Continental Express Inc.	**Operating Certificate(s) Held:**	Flag carrier (121)
Operator Does Business As:	N/A	**Operator Designator Code:**	C2XA

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	SJT,1917 ft msl	**Distance from Accident Site:**	
Observation Time:	12:53 Local	**Direction from Accident Site:**	
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	9 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	190°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30 inches Hg	**Temperature/Dew Point:**	36°C / 13°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	HOUSTON, TX (IAH)	**Type of Flight Plan Filed:**	IFR
Destination:	San Angelo, TX (SJT)	**Type of Clearance:**	IFR
Departure Time:	11:45 Local	**Type of Airspace:**	Class A

Airport Information

Airport:	San Angelo Regional SJT	**Runway Surface Type:**	
Airport Elevation:	1917 ft msl	**Runway Surface Condition:**	Unknown
Runway Used:		**IFR Approach:**	Unknown
Runway Length/Width:		**VFR Approach/Landing:**	Straight-in

Wreckage and Impact Information

Crew Injuries:	1 Minor, 2 None	**Aircraft Damage:**	None
Passenger Injuries:	20 None	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 Minor, 22 None	**Latitude, Longitude:**	31.610746,-100.550926(est)

Administrative Information

Investigator In Charge (IIC):	Ragogna, Jason
Additional Participating Persons:	Klaus F Drake; Federal Aviation Administartion; San Antonio, TX Paul A Sloke; Federal Aviation Administration; Houston, TX Fred Junek; Continental Express Airlines; Houston, TX Manuel S Montiero; Embraer Aircraft Corporation; Fort Lauderdale, FL
Original Publish Date:	June 3, 2002
Last Revision Date:	
Investigation Class:	Class
Note:	The NTSB traveled to the scene of this incident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=49978