National Transportation Safety Board
Aviation Accident Final Report

Location:	Manchester, NH	**Accident Number:**	NYC06FA027
Date & Time:	11/08/2005, 0725 EST	**Registration:**	N7801Q
Aircraft:	EMBRAER 110P1	**Aircraft Damage:**	Destroyed
Defining Event:		**Injuries:**	1 Serious
Flight Conducted Under:	Part 135: Air Taxi & Commuter - Non-scheduled		

Analysis

According to the pilot, the airplane took off with a flaps setting of 25 percent, per the operator's procedures at the time. He stated that, immediately after raising the landing gear after takeoff, he heard an explosion and saw that all gauges for the left engine, a Pratt & Whitney Canada (P&WC) PT6A-34, pointed to zero, indicating a loss of power to the left engine. He also noted that the left propeller had completely stopped so he added full power to the right engine, left the flaps at 25 percent, and left the landing gear up. He further stated that, although he "stood on the right rudder," he could not stop the airplane's left turning descent. The pilot later noted that, after the left engine lost power, he "couldn't hold V speeds" and "the stall warning horn was going off the whole time."

Postaccident examination of the accident airplane's left engine revealed that that it had failed and that the propeller had been feathered. Examination of the trim positions revealed that the rudder was at neutral trim and the aileron was at full left trim. Although these trim positions could have been altered when the wings separated from the fuselage during ground impact, the pilot's comment that he "stood on the rudder" suggests that he either had not trimmed the airplane after the engine failure or had applied trim opposite the desired direction. The activation of the stall warning horn and the pilot's statement that he "couldn't hold V speeds" indicate that he also did not lower the nose sufficiently to maintain best single-engine rate of climb or best single-engine angle of climb airspeed. In addition, a performance calculation conducted during the National Transportation Safety Board's investigation revealed that the airplane, with flaps set at 25 degrees, would have been able to climb at more than 400 feet per minute if the pilot had maintained best single-engine rate of climb airspeed and if the airplane had been properly trimmed.

Postaccident examination of the accident airplane's left engine revealed fatigue fracturing of the first-stage sun gear.[1] According to the airplane's maintenance records, during an October 1998 engine overhaul, the first-stage planet gear assembly was replaced due to "frosted and pitted gear teeth." The planet gear assembly's mating sun gear was also examined during overhaul but was found to be serviceable and was reinstalled with the new planet gear assembly, which was an accepted practice at the time. However, since then, the engine

manufacturer determined that if either the sun gear or planet gear assembly needed to be replaced with a zero-time component, the corresponding mating gear/assembly must also be replaced with a zero-time component; otherwise, the different wear patterns on the gears could potentially cause "distress" to one or both of the components.

Review of maintenance records showed that the engines were maintained, in part, under a Federal Aviation Administration (FAA)-approved "on-condition" maintenance program;[2] Business Air's maintenance program was approved in May 1995. In April 2002, P&WC, the engine manufacturer, issued Service Bulletin (SB) 1403 Revision 7, which no longer mentioned on-condition maintenance programs and required, for the first time for other time between overhaul extension options, the replacement of a number of PT6A-34, -35, and -36 life-limited engine components, including the first-stage sun gear at 12,000 hours total time since new. The first-stage sun gear on the accident airplane failed at 22,064.8 hours.

In November 2005 (when the Manchester accident occurred), Business Air was operating under an engine on-condition maintenance program that did not incorporate the up-to-date PT6A 34, -35, and -36 reliability standards for the life-limited parts listed in SB 1403R7 because the SB did not address previously approved on-condition maintenance programs. Three months later, in an e-mail message to Business Air, P&WC stated that it would continue to "endorse" Business Air's engine on-condition maintenance program. Although SB 1403R7 improves PT6A-34, -35, and -36 engine reliability standards, allowing grandfathered on-condition maintenance programs for these engines is less restrictive and does not offer the same level of reliability.

The National Transportation Safety Board's review of maintenance records further revealed numerous deficiencies in Business Air's on-condition engine maintenance program that appear to have gone undetected by the Portland, Maine, Flight Standards District Office (FSDO), which is in charge of monitoring Business Air's operations. For example, one infraction was that Business Air did not specify which parts were included in its on-condition maintenance program and which would have been removed by other means, such as hard-time scheduling.[3] Also, the operator used engine condition trend monitoring as part of determining engine health; however, review of records revealed missing data, inaccurate data input, a lack of regular trend analyses, and a failure to update trends or reestablish baselines when certain maintenance was performed. Another example showed that, although Business Air had an engine-oil analysis program in place, the time it took to send samples for testing and receive results was lengthy. According to maintenance records, the operator took an oil sample from the accident engine more than 2 weeks before the accident and sent it for testing. The oil sample, which revealed increased iron levels, would have provided valuable information about the engine's health. However, the results, which indicated a decline in engine health, were not received until days after the accident.

If the FAA had been properly monitoring Business Air's maintenance program, it may have been aware of the operator's inadequate maintenance practices that allowed, among other things, an engine with a sun gear well beyond what the manufacturer considered to be a reliable operating timeframe to continue operation. It also took more than 2 1/2 years after the accident for the FAA to finally present a consent order[4] to the operator, in which both parties not only acknowledged the operator's ongoing maintenance inadequacies but also the required corrective actions.

[1] A sun gear is the center gear around which an engine's planet gear assembly revolves; together, the sun gear and planet gear assembly provide a means of reducing the engine's rpm to the propeller's rpm.

[2] According to FAA Advisory Circular (AC) 120-17A, "Maintenance Control by Reliability Methods," under on-condition maintenance programs, components are required to be periodically inspected or checked against some appropriate physical standard to determine whether they can continue in service.

[3] According to FAA AC 120-17A, "Maintenance Control by Reliability Methods," under hard-time maintenance programs, components are required to be periodically overhauled or be removed from service.

[4] A consent order is a voluntary agreement worked out between two or more parties to a dispute. It generally has the same effect as a court order and can be enforced by the court if anyone does not comply with the orders.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: The pilot's misapplication of flight controls following an engine failure. Contributing to the accident was the failure of the sun gear, which resulted in the loss of engine power. Contributing to the sun gear failure were the engine manufacturer's grandfathering of previously recommended, but less reliable, maintenance standards, the Federal Aviation Administration's (FAA) acceptance of the engine manufacturer's grandfathering, the operator's inadequate maintenance practices, and the FAA's inadequate oversight of the operator.

Findings

Occurrence #1: LOSS OF ENGINE POWER(TOTAL) - MECH FAILURE/MALF
Phase of Operation: CLIMB

Findings
1. (C) EMERGENCY PROCEDURE - NOT FOLLOWED - PILOT IN COMMAND
2. (F) REMEDIAL ACTION - IMPROPER - PILOT IN COMMAND
3. (F) REDUCTION GEAR ASSY,REDUCTION GEAR BEARING - FAILURE

Occurrence #2: LOSS OF CONTROL - IN FLIGHT
Phase of Operation: DESCENT - UNCONTROLLED

Occurrence #3: IN FLIGHT COLLISION WITH OBJECT
Phase of Operation: DESCENT - UNCONTROLLED

Findings
4. OBJECT - BUILDING(NONRESIDENTIAL)

Factual Information

HISTORY OF FLIGHT

On November 8, 2005, about 0725 eastern standard time, an Embraer 110P1, N7801Q, operated by Business Air, Incorporated as AirNow flight 352, was destroyed when it impacted a department store garden center shortly after takeoff from Manchester Airport (MHT), Manchester, New Hampshire. The certificated airline transport pilot was seriously injured. Visual meteorological conditions prevailed, and an instrument flight rules flight plan had been filed for the flight to Bangor International Airport (BGR), Bangor, Maine. The unscheduled cargo flight was being conducted under the provisions of 14 Code of Federal Regulations Part 135.

According to the pilot, the preflight inspection, start-up, taxi and takeoff from runway 6 with flaps set at 25 percent were all normal. However, just after raising the landing gear, the pilot heard an explosion from what he thought was the right engine. But when he checked the engine instruments, he saw that all of the gauges for the left engine indicated zero. The pilot then visually checked the left engine and saw that the left propeller had completely stopped. The pilot retarded the left power lever, but never had time to shut off the condition lever.

The pilot added full power to the right engine, left the flaps at 25 percent, and left the landing gear up. The airplane began a "shallow" left turn, and although the pilot "stood on the right rudder," he could not stop a left turning descent. (When interviewed, the pilot could not recall the position of the yoke.) The pilot advised the tower of the emergency, requested a landing back at the airport, and was issued a clearance to land on runway 17. However, before the pilot could fly the airplane back to the airport, it descended into the garden center. The pilot also noted that after the loss of engine power, he "couldn't hold V speeds" and "the stall warning horn was going off the whole time." When asked about the airplane's maximum altitude, he "guess[ed] around a thousand feet."

In the garden center, the airplane struck several tractor trailer-sized metal storage containers. The cockpit separated from the rest of the fuselage, slid through the back fence and out of the garden center, and came to a stop on its right side. The pilot undid his harness, fell down to the right side, and crawled out the back opening, where bystanders helped move him away from the wreckage.

AIRPLANE INFORMATION

The airplane was a 1979 Embraer (EMB) 110P1 Bandeirante, powered by two Pratt and Whitney Canada (P&WC) PT6A-34 engines. The airplane had been converted from a passenger configuration to a cargo carrier and was carrying small packages at the time of the accident.

Business Air EMB110P1s were modified, in part, via Supplemental Type Certificate (STC) SA01184AT, which involved the removal of passenger windows and overwing exits, and the modification of airstair doors. Listed under "Limitations and Conditions," was: "Airplanes modified with this STC must be maintained with an Approved Aircraft Inspection Program [AAIP] for FAR Part 135."

Per FAA Advisory Circular (AC) 135-10A, AAIP pertains to "aircraft of nine or less passenger seats operated under FAR Part 135."

According to FAA Type Certificate Data Sheet No A21SO, for the EMB-110P1, Note 9, "Cargo

version must be maintained in accordance with the original certification requirements of a 10 or more passenger aircraft."

A review of maintenance records revealed that the airplane's left engine was overhauled in October 1998. At that time, the "power section was completely dismantled for full overhaul inspection in accordance with the overhaul requirements." The 1st stage planet gear assembly was replaced due to "frosted and pitted gear teeth." The sun gear was found to be serviceable, and was reinstalled along with a new planet gear assembly.

On September 2, 1999, P&WC issued Service Information Letter (SIL) PT6A-079 to advise all operators of an overhaul manual change that addressed first stage sun gear and planet gear reliability. According to the Letter, experience indicated "an increasing rate of unplanned removals due to first stage sun/planet gear distress following an overhaul where only the first stage sun gear or planet gears and not both were replaced." In the majority of distress cases, the first stage sun or planet gears had been matched with replacement "zero time" sun or planet gears. The Letter further stated that each engine model's corresponding overhaul manual would be changed to require the replacement of the sun and planet gears as a set should one of them be found unserviceable. In May 2000, the engine overhaul manual was updated.

Time since overhaul of the left engine power section was calculated to be 4,161 hours.

Automatic Feathering

The airplane was equipped with an automatic feathering system. According to the Airplane Flight Manual (AFM), if armed, and should the engine torque drop below 200, plus or minus 50 foot-pounds, an automatic feathering solenoid would be energized and the propeller would feather.

"Autofeather - Set" was part of the Before Takeoff Checklist.

Trim Controls

There were trim controls in the Bandeirante for all three flight axes, located on the center pedestal. The elevator trim was located on the left side of the pedestal, and consisted of a wheel that rotated in a fore and aft plane. Next to the elevator trim was the rudder trim, which consisted of a palm-sized wheel that rotated left and right. Below and aft of the rudder trim was aileron trim, which also consisted of a palm-sized wheel that rotated left and right.

Takeoff Weight

The takeoff weight of the airplane for the accident flight was calculated to be 11,554 pounds. The maximum gross weight of the airplane was 12,500 pounds.

Single Engine Airspeeds

The single engine best angle of climb airspeed (Vxse) at 11,500 pounds was calculated to be 104 knots. The single engine best rate of climb airspeed (Vyse) at 11,500 pounds was calculated to be 110 knots.

Stall Warning Horn

According to the AFM, the stall warning horn would have been energized between 5 and 10

knots above stalling speed. Indicated stall speed at 11,500 pounds with the landing gear up and flaps 25 percent was 83 knots at 0 degrees angle of bank, and 90 knots at 30 degrees angle of bank.

Takeoff Flap Setting

Avior Corporation, Incorporated, an affiliate company of Business Air and based at the same location, converted Embraer passenger airplanes into cargo airplanes via a series of FAA-approved STCs. One of the STCs, for single pilot operations, required the issuance of a Flight Manual Supplement. Supplement Limitations included: "Takeoff and Landing data, and checklist placards are required." One of the required placards included V speeds at various weights, and at the bottom stated, "Note: Vr at all weights, flaps 25 percent = 85 knots." The Supplement was approved by the Boston Aircraft Certification Office in January 2001.

Landing Gear Warning System

According to the AFM, "If at least one of the power levers is brought below an Ng range between 75 and 78 percent, while one landing gear strut is not in its downlocked position, this will be enough to make the system blow the horn and illuminate a red light on the annunciator panel (LANDING GEAR)."

Engine Chip Detectors

As originally certificated on the Bandeirante, the engines were equipped with chip detectors; however, per original type design, they were not connected to any cockpit warning systems.

PILOT INFORMATION

The pilot held an airline transport pilot certificate with a multi-engine rating and an EMB-110 rating. According to the pilot, he had previously flown Part 135 operations in Texas and Michigan, and had been part owner of a Piper Navajo operation in North Carolina prior to his employment with Business Air. He had been with the company about 5 months.

According to company records, the pilot had logged 3,612 total flight hours, with 137 hours in the EMB-110, and had flown his captain's check ride in July 2005.

The pilot's latest FAA first class medical certificate was issued on April 4, 2005.

Before the accident, the pilot had been scheduled to take assistant chief pilot training at company headquarters, to assume that position for the company's Cessna 208 operations in its southern region.

On one of his prior training flights, on July 23, 2005, the pilot performed a practice emergency descent. According to the instructor’s comments: “Recovery needs work – loss of airspeed. More aggressive on nose down att[itude].”

RADAR AND VIDEO INFORMATION

Due to the terrain, no radar track information was available. In addition, a check of local businesses and airport facilities revealed that no security cameras or ATM machine cameras were pointed at the airplane during the accident sequence.

According to a supervisor at Boston Approach Control, Manchester Sector, the radar computer system might be able to process a primary "skin paint" about 500 feet, but an altitude readout would not be present until 900 to 1,000 feet.

METEOROLOGICAL INFORMATION

Weather, reported at the airport at 0653, included calm winds, visibility 10 statute miles, broken clouds at 11,000 feet, temperature 7 degrees Celsius (C), and dew point -1 degree C.

Weather, reported at the airport at 0753, included winds from 270 degrees true at 5 knots, 10 statute miles visibility, scattered clouds at 8,000 feet, temperature 10 degrees C, and dew point -1 degree C.

WRECKAGE AND IMPACT INFORMATION

The accident site was located about 6/10 nautical mile, 010 degrees magnetic from the departure end of runway 6, in the vicinity of 42 degrees, 56.9 minutes north latitude, 71 degrees, 26.4 minutes west longitude.

The wreckage path, which was oriented toward 190 degrees magnetic, began at the top of a parking lot light stanchion, about 60 feet from the garden center. Damage continued along the garden center roof and included two more light stanchions. Past the roof, there were impact marks on numerous 40-foot, tractor trailer-sized metal storage containers that lined both sides of a pathway that led to a chain link security fence. The initial width of the pathway was estimated to be about 30 feet. The containers on the left side of the pathway were aligned along the department store wall, while the line of storage containers on the right side of the pathway angled away from the wall by an estimated 30 degrees.

An indentation, consistent with the position of the airplane's left wing, was found in the first container on the left side of the wreckage path. There were also scrape marks on the top of the container.

The left wing, including the left engine, was found fractured in sections, along the containers on the right side of the wreckage path. Further along, next to the containers on the left side of the pathway, was a turned-over and charred forklift. Next to the forklift were the charred remains of the right engine. Just beyond the forklift was a destroyed section of the chain-link security fence, containing the burnt remains of the airplane's right wing and center wing/fuselage section. Next to those were the mostly-charred remnants of the airplane's empennage.

About 60 feet beyond the empennage, was the airplane's unburned cockpit area, laying on its right side.

The left engine propeller hub was still attached to its engine. The propeller blades appeared to be angled about 90 degrees from the direction of rotation, and there was no significant leading edge damage to the propeller blades, consistent with the propeller having been feathered.

The right engine propeller hub was detached from the engine, and one propeller blade was separated about 8 inches from the tip, while the other blades exhibited curling, missing blade material and leading edge damage. The blades also appeared to be angled 90 degrees from the direction of rotation.

Control surface actuator positions were measured on the accident airplane, then correlated to a similar airplane at company headquarters. The resultant trim positions observed were: flaps were at 25 percent, the rudder at neutral trim, and aileron was at full left trim. However, the airplane's break-up sequence could have altered the in-flight trim positions.

TESTS AND RESEARCH

Climb Performance

Embraer engineers calculated the airplane's rate of climb performance based on 25 percent flaps, a takeoff weight of 11,550 pounds for the accident airplane, and the ambient conditions at the time of the accident. With an inoperative and feathered engine, the airplane should have been able to climb at 445 feet per minute.

Engine Out Performance

According to the STC placard mounted in the airplane, Vxse for 11,500 pounds was 104 knots, and Vyse was 110 knots. Utilizing the Bandeirante AFM Stall Speed Chart, and a "shallow" (15 degrees) angle of bank, landing gear up, flaps 25 percent, the stall speed for the airplane, if trimmed, would have been about 87 knots.

Engine Examinations

The two engines were examined in Montreal, at P&WC facilities, on December 6 and 7, 2005, with Safety Board oversight.

The right engine compressor turbine shroud exhibited rubbing marks. There was heavy rubbing/scoring damage on the compressor turbine disk rear face and turbine blade trailing edges. The power turbine shroud exhibited heavy circular scoring, and the power turbine had severe rubbing/scoring on the disk upstream face. All power turbine blades were fractured.

The left engine compressor turbine shroud exhibited some light material deposits adhering to the surfaces, and the compressor turbine blades exhibited tip burning with partial breakage. The power turbine shroud was heavily gouged and punctured. The power turbine disk was found angled approximately 45 degrees from its normal operating plane. There was also evidence of impact damage, but no evidence of rotational scoring.

An examination of the reduction gearing from the left engine revealed that the sun gear was fractured at three locations: one within the teeth and two along the shaft. The sun gear teeth were completely worn off about 1/4 the width of the gear. The remaining portions of teeth were also partially worn off, approximately 180 degrees around the gear. There was also heavy gear tooth damage to the 1st stage planet gears, with many of the teeth fractured.

The planet gears and sun gear were further examined at the P&WC Materials Laboratory. According to the Laboratory Report, the planet gears exhibited severe battering and multiple tooth fractures, and the sun gear was fractured radially within the teeth.

The sun gear fracture exhibited fatigue cracking in the root of the filet radius. A fractured tooth almost diametrically opposite of the radial fracture also exhibited fatigue in the filet radius on drive side of the tooth.

The planet gears exhibited numerous fractured teeth, which displayed features indicative of fatigue originating at the root filet radius on the drive side. The remaining battering was considered secondary.

Under high magnification, the fracture surfaces on the sun gear and one of the planet gears revealed the presence of fine striations, consistent with high cycle fatigue.

Chemical composition and hardness, as well as the depth of the finished case of the sun gear and one examined planet gear met the drawing requirements.

Debris found on the engine chip detector was identified as an iron-based alloy similar to

reduction gear material, aluminum alloy similar to air seal material, and magnesium alloy similar to reduction gearbox housing material.

MAINTENANCE INFORMATION

Maintenance Reliability

FAA Advisory Circular (AC) 120-17A, “Maintenance Control by Reliability Methods,” initiated by Flight Standards Service (AFS)-230, provides “information and guidance material which may be used to design or develop maintenance control programs utilizing reliability control methods.”

The AC, which was issued in 1978, addresses approved aircraft maintenance programs to those operators subject to the provisions of Federal Air Regulations Parts 121 and 127. However, even though it wasn’t directed toward Part 135 operations, the AC nevertheless addressed some of the same maintenance processes that Business Air might have utilized:

1) "Hard Time…is a primary maintenance process. It requires that an appliance or part be periodically overhauled in accordance with the carrier's maintenance manual or be removed from service."

2) "On Condition…is a preventive primary maintenance process. It requires that an appliance or part be periodically inspected or checked against some appropriate physical standard to determine whether it can continue in service. The purpose of the standard is to remove the unit from service before failure during normal operation occurs.”

3) "Condition Monitoring…is a maintenance process for items that have neither 'Hard Time' nor 'On Condition' maintenance as their primary maintenance process. [It] is accomplished by appropriate means available to an operator for finding and solving problem areas."

Recommended Time Between Overhaul (TBO)

P&WC Service Bulletin 1403, (SB1403), originally issued March 12, 1981, with revision 7 (R7) issued April 12, 2002, indicated that the "basic industry" TBO for the PT6A-34 engine was 4,000 hours. The TBO could, however, be extended, subject to the operator's "Airworthiness Authority."

On-Condition Background Information

Before SB1403R7, P&WC supported the use of progressive overhauls and on-condition maintenance programs for PT6A-34 and -36 operators. The program required a technical recommendation from P&WC regarding the operator’s proposed maintenance program, and subsequently, a final approval from the operator’s airworthiness authority, in this case, the Portland, Maine, Flight Standards District Office (FSDO).

In 1994, Business Air submitted an engine maintenance program to P&WC for review. On August 23, 1994, P&WC provided comments to the proposed program, and noted that the “implementation of the program and its removal schedule is subject to your local Airworthiness Authority.” Follow-up letters to the operator in January 1995 and February 1995 from P&WC confirmed the manufacturer’s “acceptance” of the elements of the program.

In May 1995, the FAA approved Business Air's engine maintenance program, and the Operations Specifications were modified to reflect approval to maintain engines with the "time in service interval" listed as "on condition," and the "maintenance document," listed in part, as

P&WC Service Bulletin 1403, “as revised.”

According to a Memorandum from the Director, Flight Standards Service, AFS-1, dated January 11, 2008, compliance with the SB became mandatory when it was specifically listed in the Ops Specs. "By listing the SB, the instructions or information stated in the SB becomes an integral part of their continuous airworthiness maintenance program or approved maintenance program and will have to be accomplished as stated."

The original approval was granted under SB1403R4, but as of the publication of SB1403R7, P&WC no longer provided recommendations for on-condition programs. SB1403R7 did, however, grandfather previous recommendations to the following extent:

“TBO extension recommendations that were approved prior to issue of this SB, per P&WC S.B. No. 1403, revisions 0 to 6, or per AGTOIL 32, are not affected and remain valid, with the conditions, restrictions, and references stated at the time they were provided.”

Although the statement appeared to only validate TBO extensions, and not on-condition programs, an email from P&WC to the operator on February 22, 2006, stated: “Today P&WC no longer provides recommendations for on-condition maintenance programs; however, P&WC continues to endorse past agreements such as that made to Business Air Inc. Therefore, agreements prior to Rev. 7 remain valid, unless waived by local airworthiness authorities.”

SB1403R7 also provided two new recommendation extension options beyond the basic 4,000-hour TBO for operators with an average engine utilization greater than 300 hours per year: “A” which involved fleet extensions, and “B” which involved individual engines. Option A required replacement of life-limited components at the next overhaul, while Option B required replacement immediately.

SB1403R7 made no mention of engines in an on-condition maintenance program.

Life-limited components included bearings number 1 through 4, power turbine blades, the first stage planet gears, and the first stage sun gear, all of which had a service life of 12,000 hours total time since new.

According to an email from a P&WC Engineering and Quality Services engineer, dated October 13, 2006, "the 12,000 operating hour replacement threshold recommended for the components listed…was established (and is maintained) primarily on the basis of part condition seen on engines submitted for overhaul. In addition, findings from unscheduled service events related to high-time components were factored in."

The sun gear on the accident airplane failed at 22,064.8 hours.

Maintenance Reliability Findings

In addition to operating the Embraer EMB-110P, Business Air operated the Cessna 208B. While the PT6A-34 engines installed on EMB-110 aircraft were maintained on the FAA-approved “on condition” program, the PT6A-114 engines installed on the six CE-208B aircraft were maintained under differing requirements. Two engines were maintained on a Maintenance On Reliable Engine (MORE) program with a Time Between Overhaul (TBO) of 8,000 hours. One engine had a prorated overhaul interval as identified on Operation Specification D082, and the remaining three engines were on yet other programs.

A review of 12, PT6A-34 engine records indicated that their average total operating time prior to incorporation onto the on-condition program was 20,000 hours, with the highest time

engine at 34,000 hours and two others at 29,500 hours. The average total time from last overhaul on engines prior to incorporation onto the program was 3,067 hours, with two engines over 6,000 hours and four engines over 4,500 hours.

Business Air utilized a P&WC Engine Condition Trend Monitoring (ECTM) as part of determining engine hot section reliability. According to the "ECTM Analytical Guide," ECTM "is a process of periodically recording engine instrument readings…then comparing them to a set of typical (predictable) engine characteristics." The Guide also notes that ECTM "is not intended for determining the serviceability of an engine."

A review of records immediately after the accident found that ECTM data was being collected. However, in the recording of the data, there was data missing, inaccurate data input, a lack of regular trend analyses and a failure to update trends or reestablish baselines when certain maintenance was performed.

As noted in AC 120-17A, on-condition maintenance “requires that an appliance or part be periodically inspected or checked against some appropriate physical standard to determine whether it can continue in service.” Business Air indicated that borescope inspections at 600-hour intervals of the combustion chamber, compressor turbine stator, compressor turbine blades, compressor turbine shroud, compared to "physical standards" noted in P&WC Maintenance Manual (MM) 72-00-00, fulfilled the requirements of an on-condition maintenance program. However, Business Air did not have established standards to remove other engine parts before failure, such as the sun gear, nor did it establish which parts were on-condition, as opposed to those which would have been removed via other means, such as hard times.

According to a representative from P&WC, there were no specific bulletins or instructions issued regarding the monitoring of the condition of the sun gear and or planet gear assembly. Instead, P&WC MM 72-00-00, under "Maintenance Practices" and "Fault Isolation," included how to monitor contaminants in the oil, how to identify the debris, and what to do with the engine when debris were identified.

Business Air utilized an oil analysis program which involved sending samples to Aviation Laboratories in Kenner, Louisiana, and receiving analysis results several weeks later via letter.

An oil sample was taken on August 4, 2005, and analyzed on August 10, 2005. According to the report results, "oil values appear normal." Iron parts per million were 0.4. On October 19, 2005, another sample was taken, and analyzed on November 1, 2005. Although the results also stated "oil values appear normal," iron parts per million had increased to 3.6. The results arrived at Business Air after the accident.

According to the president of Business Air, following the accident, the timeliness of receiving the results was improved after changing the method of receipt to email. In addition, oil filter debris and patch tests were incorporated every 300 hours of operation. Finally, a Chadwick 192A vibration analysis was incorporated for every 600 hours of operation, to identify internal rotating components that could be deteriorating.

Business Air utilized a commercially-available web-base subscribed program, “MX Manager,” for the two aircraft types to track all Airworthiness Directives, time controlled maintenance actions including inspection intervals, and time controlled components. An audit of the Airworthiness Directives on both fleet types revealed full compliance. However, some component times could not be tracked back to zero, thus hampering the ability to substantiate

the times actually accrued on life-limited parts.

Business Air had an approved Minimum Equipment List (MEL) for each aircraft type. A review of open and closed Lists revealed no adverse findings.

An examination of an exemplar aircraft Weight and Balance record indicated accurate calculations.

Business Air employed a total of 10 aircraft mechanics, with two of those located at an outstation in Manchester, New Hampshire. An examination of mechanic training records revealed that they were current and well organized.

According to P&WC Maintenance Manual Part number 3021242, engine preservation "depends on the period of inactivity and whether or not the engine may be rotated during the inactive period. An engine is considered inactive when it has not been operated either on the ground, or in flight for a minimum of ten minutes after the oil temperature has stabilized. The expected period of inactivity should be established and reference made to the Engine Preservation Procedures. The preservation should be recorded in the engine logbook and on tags fastened to the engine."

According to the Business Air PT-6A-34 P&WC Engine Maintenance Program, Section 6, test cell runs were required for engines being incorporated into the program that were in long term storage without proper preservation, those previously operated under Part 91, or those that previously had a utilization of less than 500 hours per year.

Fourteen engines, over a period of approximately 10 years, were found to have been lacking preservation documentation prior to induction into Business Air's maintenance program, with inactivity exceeding 1 year in three cases, and 2 years in two cases. There was also no documentation of any test cell runs for those engines.

A review of the operator's PT6A-34 Engine Maintenance Program noted that, on the "Highlights of Revision" page, very few changes to pages were made through revision 3, approved September 10, 2002. However, revision 4 was approved on December 9, 2004, revision 5 approved on January 4, 2006 and revision 6 was approved on July 20, 2006.

A comparison between revision 3 and revision 6 revealed that at least 10 maintenance requirements were either deleted or lessened. However, there was no documented justification for the changes as required by FAA Order 8300.10 (since replaced by FAA Order 8900.1.)

FAA Corrective Actions

On July 15, 2008, FAA and Business Air agreed to an FAA-initiated Consent Order. Excerpts, less paragraph 2, include:

"1. The FAA, acknowledging that Business Air has taken significant steps towards resolving concerns held by the agency regarding the safety of Business Air operations, also recognizes that Business Air in cooperation with the FAA, has accomplished the following:

A. A review of Business Air's single pilot STC (No. SA00039BO), resulting in an approved change to the pilot panel configuration, and included equipment changes.

B. Approval for installation of an approved supplemental oxygen system.

C. Approved modification to aircraft inverter systems to accommodate aircraft configuration.

D. Approved aircraft modifications to install engine chip detectors. [FAA subsequently clarified this item to include instrument panel mounted warning lights; the engine chip detectors were already installed.]

E. Enhanced oil sample procedures, including a more detailed oil sample, and timely data transfer.

F. Incorporation of a program regarding vibration testing for PT6A engine power sections.

G. Removing high time power sections; those above 10,000 hours TSO, from service. Agreeing that all new engines placed into service will be below 4,000 hours TBO.

H. Developing programs based on current "System Safety" philosophies through the aid of a consultant.

I. Adoption of an Air Carrier Manual (ACM) that accomplishes the same function as a General Maintenance Manual for Part 135 (10 or more).

J. Implementation of a critical component inspection review program that accomplishes the RII functions in Part 135 (10 or more).

K. Added the position of Director of Safety.

...

3. As part of this Consent Order, Business Air agrees to accomplish the following:

A. Within the noted individual compliance times following Business Air's signature on this Consent Order, Business Air will present to the FAA:

1. A revised engine maintenance program (AAIP) that establishes a reliability basis for the fleet. The present Business Air PT6A Pratt & Whitney Engine Maintenance Program will be modified, to at the minimum, incorporate a periodic comparison to an acceptable standard. Pratt & Whitney recommended maintenance procedures, as described in its service bulletins, will be considered for incorporation into Air Now's maintenance program schedules. Changes to Business Air's maintenance program will be implemented only after FAA approval. Compliance time: 90 days.

2. An acceptable maintenance training program to be incorporated into Business Air's maintenance manual, similar to that required for FAR Part 145. Management must develop the training program or procure an acceptable training program from a commercial source. The training program must also provide for Management approval of future training program development. The training program must require Management responsibility for program success and continual process improvement. Compliance time: 90 days.

3. Acceptable procedures for incorporating newly acquired engines into the Business Air Maintenance Program. Compliance time: 90 days.

4. Present to the FAA an acceptable program that ensures management oversight and responsibility for recording aircraft discrepancies and completion of repairs. (Post accident EIR related). Compliance time: 60 days.

5. Develop an acceptable program for tracking and maintaining the manual revisions that include self disclosure and comprehensive fixes. Compliance time: 60 days.

4. Business Air further agrees that should it fail to perform any of the above within any of the noted time frames, that Business Air will be in breach this agreement. Further, as a result of said breach, Business Air agrees that it will not appeal any or all of the following actions if taken by the FAA. A specific written Letter of Agreement (LOA) may be used, at the FAA's discretion, to modify the conditions of breach of this agreement.

A. An immediate maintenance manual and Operations Specification (OPSS) revision that imposes an engine overhaul requirement of overhaul every 4000 hours.

B. An immediately effective operations manual and OPSS revision to suspend Business Air's pilot training program.

C. Business Air agrees that it has operated aircraft with open maintenance discrepancies, and failed to document maintenance discrepancies in the applicable aircraft record."

ADDITIONAL INFORMATION

Engine Failure Procedures

According to the AFM Emergency Procedures section, under "Engine Failure During Takeoff," section "B. Decision to Continue Takeoff":

Power Levers - Max permissible torque

Airspeed to leave ground - 85 IAS knots

Directional Control - Maintain

Landing Gear - UP (after positive rate of climb)

Airspeed - Accelerate to Vxse

After climb to safe altitude:

Flaps - 0 percent

Speed - Accelerate to Vyse

Affected engine - Identify/shut-down checklist

Autofeather switch - Off

Hydraulic booster pump - Off

Following the accident, the president of Business Air indicated in a letter to the company's FAA Principal Operations Inspector, that henceforth, it would utilize 0 percent flaps for all takeoffs.

AC 120-16E, "Air Carrier Maintenance Programs"

The AC, updated by AFS-300 on September 11, 2008, "describes the scope and content of air carrier aircraft maintenance programs." According to paragraph 602 a.(2),

"A scheduled maintenance task is a maintenance action that you perform at regular, scheduled intervals so that you can ensure the item can continue to perform its intended function within its operating context, or so you can discover a hidden failure, or to ensure that a hidden function is available. You should not use terms such as hard time, on-condition, or condition monitored in your maintenance schedule. These terms represent obsolete 1960s technology, are vague, and do not describe the maintenance task you are performing. If your maintenance schedule contains these terms, there is a risk that the scheduled maintenance you want and

need may not be the maintenance that is being performed."

Pilot Information

Certificate:	Airline Transport	**Age:**	32, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	Seatbelt, Shoulder harness
Instrument Rating(s):	Airplane	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	No
Medical Certification:	Class 1	**Last Medical Exam:**	04/01/2005
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	06/01/2005
Flight Time:	3612 hours (Total, all aircraft), 137 hours (Total, this make and model), 24 hours (Last 30 days, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Manufacturer:	EMBRAER	**Registration:**	N7801Q
Model/Series:	110P1	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	No
Airworthiness Certificate:	Transport	**Serial Number:**	110-228
Landing Gear Type:	Retractable - Tricycle	**Seats:**	2
Date/Type of Last Inspection:	07/01/2005, AAIP	**Certified Max Gross Wt.:**	12500 lbs
Time Since Last Inspection:	138 Hours	**Engines:**	2 Turbo Prop
Airframe Total Time:	25704 Hours	**Engine Manufacturer:**	Pratt & Whitney Canada
ELT:	Installed, not activated	**Engine Model/Series:**	PT6A-34
Registered Owner:	Business Air, Inc.	**Rated Power:**	750 hp
Operator:	Business Air, Inc.	**Air Carrier Operating Certificate:**	Commuter Air Carrier (135)
Operator Does Business As:	AirNow	**Operator Designator Code:**	BQTA

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual Conditions	**Condition of Light:**	Day
Observation Facility, Elevation:	MHT, 266 ft msl	**Observation Time:**	0753 EST
Distance from Accident Site:	1 Nautical Miles	**Direction from Accident Site:**	240°
Lowest Cloud Condition:	Scattered / 8000 ft agl	**Temperature/Dew Point:**	10°C / -1°C
Lowest Ceiling:		**Visibility**	10 Miles
Wind Speed/Gusts, Direction:	5 knots, 270°	**Visibility (RVR):**	
Altimeter Setting:	29.95 inches Hg	**Visibility (RVV):**	
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Manchester, NH (MHT)	**Type of Flight Plan Filed:**	IFR
Destination:	Bangor, ME (BGR)	**Type of Clearance:**	IFR
Departure Time:	0725 EDT	**Type of Airspace:**	

Airport Information

Airport:	Manchester (MHT)	**Runway Surface Type:**	Asphalt
Airport Elevation:	266 ft	**Runway Surface Condition:**	Dry
Runway Used:	06	**IFR Approach:**	None
Runway Length/Width:	6850 ft / 150 ft	**VFR Approach/Landing:**	Forced Landing

Wreckage and Impact Information

Crew Injuries:	1 Serious	**Aircraft Damage:**	Destroyed
Passenger Injuries:	N/A	**Aircraft Fire:**	On-Ground
Ground Injuries:	N/A	**Aircraft Explosion:**	On-Ground
Total Injuries:	1 Serious	**Latitude, Longitude:**	42.948333, -71.440000

Administrative Information

Investigator In Charge (IIC):	Paul R Cox	**Adopted Date:**	09/30/2009
Additional Participating Persons:	Eric West; FAA/AAI-100; Washington, DC Elaine Summers; Accredited Representative/TSB Canada; Ottawa, Ontario, Doug Hardy; P&W Canada/Advisor to Accred Rep; Montreal, Quebec, Raul Moreira Neto; CENIPA/Accredited Representative; Brasilia, Brasil, Mark Lowell; Embraer/Advisor to Brasil Accred Rep; Ft. Lauderdale, FL Steve McClure; Business Air, Inc; Bennington, VT		
Publish Date:	10/01/2009		
Investigation Docket:	NTSB accident and incident dockets serve as permanent archival information for the NTSB's investigations. Dockets released prior to June 1, 2009 are publicly available from the NTSB's Record Management Division at pubinq@ntsb.gov, or at 800-877-6799. Dockets released after this date are available at http://dms.ntsb.gov/pubdms/.		

The National Transportation Safety Board (NTSB), established in 1967, is an independent federal agency mandated by Congress through the Independent Safety Board Act of 1974 to investigate transportation accidents, determine the probable causes of the accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation. The NTSB makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

The Independent Safety Board Act, as codified at 49 U.S.C. Section 1154(b), precludes the admission into evidence or use of any part of an NTSB report related to an incident or accident in a civil action for damages resulting from a matter mentioned in the report.