National Transportation Safety Board
Aviation Accident Final Report

Location:	Lake Michigan, United States	**Accident Number:**	CHI05MA011
Date & Time:	10/20/2004, 2029 CDT	**Registration:**	N709CK
Aircraft:	Boeing 747-132	**Aircraft Damage:**	Substantial
Defining Event:		**Injuries:**	5 None
Flight Conducted Under:	Part 121: Air Carrier - Non-scheduled		

Analysis

The Boeing 747-132, operated as an unscheduled domestic cargo flight under 14 CFR Part 121, was climbing through 15,000 feet mean sea level when the number one engine separated from its forward and aft engine mounts resulting in substantial damage to the airplane. The flight diverted to an alternate airport where it landed without further incident. Examination of the engine revealed an uncontained separation of an approximately 180-degree arc of the second stage turbine disk rim. The missing section of the rim coincided with circumferential rub marks on the second stage turbine disk that corresponded to rub marks on the rear inner rails of the second stage turbine vanes. The rubbed areas of the disk and vanes did not exhibit heat cracking consistent with a relatively long time period of rubbing relative to a sudden disk-to-vane contact. The fan rotor bearing did not exhibit rotational distress. The engine did not exhibit any evidence of a blade separation, case rupture, or any other uncontainment. The second stage retaining bolts are coated with a baked-on antiseize compound, FelPro C-200, during manufacture. Metallurgical exam of the second stage turbine bolts revealed cracking in the head-to-shank fillet radius and the presence of silver consistent with Silver Goop. Silver Goop is an anti-seize compound not authorized by the engine manufacturer for use in the high-pressure turbine area but is authorized in the low-pressure compressor area due to the catalytic properties of silver with wet FelPro C-200 resulting in a corrosive mixture that can contribute to bolt fractures. The induced loads from the second stage disk rim separation were estimated to have been 3.6 - 6.6 times greater than to those induced by a fan blade separation. The accident operator purchased an engine as-is and that according to maintenance records was not preserved when it was removed from an airplane belonging to another operator about 5 years prior to the accident. The high-pressure turbine (HPT) module was removed from this engine and installed on one of the accident operator's other engines prior to it being removed and then installed on the accident airplane engine. The accident operator's examination of the HPT was limited to a visual inspection that would not have detected a vane shift or ascertained the integrity second stage turbine vane assembly.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be:

The number one engine separated from the airplane during climb due to the uncontained separation of a portion of the second stage turbine disk rim after the second stage turbine vanes contacted the disk. The second stage turbine vanes contacted the second stage turbine disk due to the operator's inadequate inspection of the high pressure turbine module and the improper repair of the module by unknown maintenance personnel.

Findings

Occurrence #1: AIRFRAME/COMPONENT/SYSTEM FAILURE/MALFUNCTION
Phase of Operation: CLIMB

Findings
1. (C) TURBINE ASSEMBLY,TURBINE WHEEL - SEPARATION
2. (C) MAINTENANCE - IMPROPER - UNKNOWN
3. (C) MAINTENANCE,INSPECTION - INADEQUATE - COMPANY MAINTENANCE PERSONNEL

Occurrence #2: IN FLIGHT COLLISION WITH OBJECT
Phase of Operation: CLIMB

Findings
4. (C) OBJECT - OTHER

Factual Information

HISTORY OF FLIGHT

On October 20, 2004, about 2029 central daylight time, a Boeing 747-132, N709CK, operated by Kalitta Air, LLC, (Kalitta Air) as flight 825, received substantial damage following a separation and loss of the number one engine while climbing through about 15,000 feet mean sea level (MSL) over Lake Michigan. The 14 CFR Part 121 non-scheduled domestic cargo flight was operating on an instrument flight rules flight plan. Night visual meteorological conditions were reported at the time of the accident. The two pilots, one flight engineer, and two flight mechanics were uninjured. The flight departed from Chicago O'Hare International Airport, Chicago, Illinois, at 2010, and was en route to John F. Kennedy International Airport, New York, New York, when it diverted to Detroit Metropolitan Wayne County Airport (DTW), Detroit, Michigan, where it landed without further incident.

The flight crew did not report any abnormal conditions prior to the engine separation. Following the engine separation, the flight crew diverted to DTW where a landing was accomplished with normal operation of the leading edge devices and trailing edge flaps.

The airplane, a Boeing 747-132, had the number one engine, a Pratt & Whitney (P&W) JT9D-7A, separate from the pylon and fall into Lake Michigan as the airplane was climbing through 15,000 feet MSL. The flight crew reported that as the airplane was climbing to flight level 180, they heard a loud bang, the airplane yawed to the left, and the number one engine cockpit indications showed that the engine had lost all power. A visual inspection by the crew of the number one engine to check for damage revealed the pylon was still in place, but the engine was missing. The airplane diverted to DTW and landed without further incident. After the airplane landed, the examination of the pylon revealed the forward portion was damaged with the entire forward bulkhead including the forward engine mounts separated from the airplane. The examination The examination also revealed that the top of the mount rails and circumferentially inclusive of the four mount bolts remained attached to the aft mount on the pylon.

AIRCRAFT INFORMATION

According to Kallita Air maintenance records the engine that separated from the airplane was a Pratt & Whitney model JT9D-7A, serial number (S/N) 662253. This engine had been installed 94.1 hours and 23 cycles prior to the event at which time the high pressure turbine (HPT) and the turbine exhaust case (TEC) modules were installed on the engine. At the time of the event, the installed HPT module had accumulated 5,727.6 hours and 1,287 cycles since United Airlines had overhauled it in September 1996. Kalitta Air maintenance records also show that particular HPT module had been swapped in and out of two of their other engines to facilitate other maintenance. According to Kalitta, they inspected the HPT module under the authority of their 14 CFR Part 121 certificate. They stated that they did not do anything to the HPT module other than a visual inspection in accordance with the maintenance manual. Kalitta Air obtained the HPT module installed on a JT9D engine , S/N 662570 from Tradewinds, a Florida-based aviation broker, and inducted it into their engine maintenance program in 2003. Tradewinds had purchased the engine from AeroTurbine who had purchased the engine as part of a group of 13 from General Electric Commercial Aviation Services (GECAS). GECAS leased

the engine and the airplane on which it was installed to Polar Air Cargo. According to Kalitta Air records, the engine was removed for stagger; but according to Polar Air Cargo, the engine was removed from the airplane in 1998 because the airplane was being scrapped because of expense. GECAS stated that they had intended to send engine SN 662570 to GE's engine maintenance facility at Cardiff, Wales, to be parted out, however the engine was never sent to Wales. GECAS had engine SN 662570 inspected by an independent consultant who determined the engine was unserviceable because of problems in the number three bearing area. According to Polar Air Cargo, at the time the airplane and engines were taken out of service, they had been having problems with the number four engine that was SN 662570. Engine SN 662570 was in storage from 1998 when it was removed from the airplane until 2003 when it was acquired by Kalitta Air. According to the maintenance records, there was no maintenance accomplished to the engine including preservation during that five year period.

WRECKAGE AND IMPACT INFORMATION

In June 2005, portions of the turbine exhaust case and low pressure turbine case were recovered from Lake Michigan, and then in August 2005, the bulk of the engine, except for the low pressure turbine (LPT), was recovered from a debris field that extended approximately 600 feet on the lake bottom at a depth of approximately 270 feet. The engine was located approximately 46.42 nautical miles on a magnetic course of 81 degrees from ORD at the following coordinates: 42 degrees 04.958 minutes North, 86 degrees 52.566 minutes West. Recovery of the engine, TEC, and LPT case was conducted by American Diving and Salvage of Chicago, Illinois. The pieces of the TEC and LPT case were shipped to the National Transportation Safety Board Materials (NTSB) Laboratory for examination. The main part of the engine was shipped to P & W's Middletown, Connecticut, facility for disassembly under the supervision of the NTSB.

The piece of the turbine exhaust case that remained on the number one engine pylon consisted of the section of the case from just forward of the forward mount rail to just aft of the rear mount rail axially to either side of the through-the-rail mount bolts. The body of the turbine exhaust case was recovered from the lake with the LPT case attached to the front flange, but was missing a section at the top of the case that corresponded with the piece of the case that remained attached to the engine pylon. There were several circumferential cracks in the case wall in front of the front mount rail and in back of the rear mount rail. The circumferential fractures did not progress along any of the weld seams. The turbine exhaust duct, or center body of the turbine exhaust case, was missing and only 3 of the 12 struts remained attached to the case. The three struts that remained attached to the turbine exhaust case and the three stub ends of missing struts were buckled. The National Transportation Safety Board Materials Laboratory report stated that all of the fractures were consistent with overload and that there was no evidence of fatigue or a material defect.

TESTS AND RESEARCH

The disassembly and examination of the engine revealed the high pressure turbine (HPT) second stage turbine disk was missing a 180-degree arc of the rim and blade posts. Additionally, the front face of the second stage turbine disk had circumferential rubs and grooves from contact with the second stage turbine vane inner support and the inner feet of the

second stage turbine vanes. Examination of the engine identified that the released section of the HPT 2nd stage disk was uncontained through the forward portion of the LPT case between the 4 and 6 o'clock locations. The fan case did not have any indications of having sustained separated fan blade impact damage. Further, the examination of the number one bearing balls showed that they had no rotational damage. Additionally, one thrust reverser jackscrew drive that was recovered and the drive motor was at the head end. Most of the second stage turbine vanes were broken or missing. There were two clusters of 15 and 28 second stage turbine vanes that remained in place in the HPT case. The vanes did not have any indications of burning or hot gas erosion. The cluster of 15 vanes that was located in the upper right quadrant of the engine had a groove worn into the rear face that got progressively deeper in the counter-clockwise direction. Additionally, the grooves in the vane feet would only line up if the vanes were tilted.

During the metallurgical examination of the second-stage turbine vane retaining bolt, the visual examination of the bolts revealed cracks in the head-to-shank fillet radius. No bolt fractures wee attributed to the observed cracking in the head-to-shank fillet radius. Additionally, the energy dispersive spectroscopy (EDS) analysis of the anti-gallant coating on the threads revealed the presence of silver in addition to molybdenum. The required anti-gallant coating on the second stage turbine vane retaining bolts contains a combination of molybdenum disulfide and lead oxide, FelPro-C200. According to P&W's metallurgist, further examination of the coating on the threads revealed the silver was in a flake form that was consistent with a silver-based thread lubricant such as Silver Goop. According to the JT9D Engine Manual, Silver Goop is not authorized in the HPT area of the engine including the second stage turbine vane retaining bolts, but is specified in the JT9D LPC.

Boeing and P&W made a joint assessment of the separation of the engine from the airplane specifically looking at why the turbine exhaust case broke up releasing the engine rather than the pylon fuse pins breaking. The point of this request was in concern to the fact that the turbine exhaust case had undergone a repair that had replaced the entire forward section of the case to improve the containment capability of the case. The joint assessment determined that the engine structure broke up before the fuse pins failed because the engine structure, specifically the forward portion of the LPT case, had been compromised with the uncontained liberation of the second-stage turbine disk rim followed by the extreme unbalance of the missing rim section and the torque loads developed by the clashing of the low-pressure turbine blades and vanes. The Boeing and P&W assessment determined that the unbalance loads generated by the missing section of the second stage turbine disk rim at climb power were 3.6 - 6.6 times greater than the separation of a full fan blade. The metallurgical examination of the turbine exhaust case showed that the metal had torn away from the area of the circumferential weld. The Boeing and P&W assessment determined the unbalance loads were so severe that they could have caused the break up of the turbine exhaust case in either the original or modified configuration.

Pilot Information

Certificate:	Airline Transport; Commercial	**Age:**	45, Male
Airplane Rating(s):	Multi-engine Land	**Seat Occupied:**	Left
Other Aircraft Rating(s):		**Restraint Used:**	Seatbelt, Shoulder harness
Instrument Rating(s):		**Second Pilot Present:**	Yes
Instructor Rating(s):		**Toxicology Performed:**	No
Medical Certification:	Class 1	**Last Medical Exam:**	07/01/2004
Occupational Pilot:		**Last Flight Review or Equivalent:**	
Flight Time:	10015 hours (Total, all aircraft), 4000 hours (Total, this make and model), 8000 hours (Pilot In Command, all aircraft), 180 hours (Last 90 days, all aircraft), 73 hours (Last 30 days, all aircraft), 8 hours (Last 24 hours, all aircraft)		

Co-Pilot Information

Certificate:	Airline Transport; Commercial	**Age:**	37, Male
Airplane Rating(s):	Multi-engine Land	**Seat Occupied:**	Right
Other Aircraft Rating(s):		**Restraint Used:**	Seatbelt, Shoulder harness
Instrument Rating(s):		**Second Pilot Present:**	Yes
Instructor Rating(s):		**Toxicology Performed:**	No
Medical Certification:	Class 1 Without Waivers/Limitations	**Last Medical Exam:**	02/01/2004
Occupational Pilot:		**Last Flight Review or Equivalent:**	
Flight Time:	8300 hours (Total, all aircraft), 247 hours (Last 90 days, all aircraft), 56 hours (Last 30 days, all aircraft), 8 hours (Last 24 hours, all aircraft)		

Flight Engineer Information

Certificate:		**Age:**	
Airplane Rating(s):		**Seat Occupied:**	
Other Aircraft Rating(s):		**Restraint Used:**	
Instrument Rating(s):		**Second Pilot Present:**	Yes
Instructor Rating(s):		**Toxicology Performed:**	
Medical Certification:		**Last Medical Exam:**	
Occupational Pilot:		**Last Flight Review or Equivalent:**	
Flight Time:			

Aircraft and Owner/Operator Information

Aircraft Manufacturer:	Boeing	**Registration:**	N709CK
Model/Series:	747-132	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	No
Airworthiness Certificate:	Transport	**Serial Number:**	20247
Landing Gear Type:	Retractable - Tricycle	**Seats:**	7
Date/Type of Last Inspection:	10/01/2004, Continuous Airworthiness	**Certified Max Gross Wt.:**	
Time Since Last Inspection:	94.1 Hours	**Engines:**	4 Turbo Fan
Airframe Total Time:	93548.7 Hours	**Engine Manufacturer:**	Pratt & Whitney
ELT:		**Engine Model/Series:**	JT9D-7A
Registered Owner:	Kalitta Air, LLC	**Rated Power:**	46150 lbs
Operator:	Kalitta Air, LLC	**Air Carrier Operating Certificate:**	Flag carrier (121)
Operator Does Business As:		**Operator Designator Code:**	KCSA

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual Conditions	**Condition of Light:**	Night
Observation Facility, Elevation:	ORD, 655 ft msl	**Observation Time:**	1956 CDT
Distance from Accident Site:		**Direction from Accident Site:**	
Lowest Cloud Condition:	Clear	**Temperature/Dew Point:**	11°C / 8°C
Lowest Ceiling:	Overcast / 1700 ft agl	**Visibility**	10 Miles
Wind Speed/Gusts, Direction:	, 10°	**Visibility (RVR):**	
Altimeter Setting:	30.12 inches Hg	**Visibility (RVV):**	
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	CHICAGO, IL (ORD)	**Type of Flight Plan Filed:**	IFR
Destination:	NEW YORK, NY (JFK)	**Type of Clearance:**	
Departure Time:	2010 CDT	**Type of Airspace:**	

Wreckage and Impact Information

Crew Injuries:	5 None	**Aircraft Damage:**	Substantial
Passenger Injuries:	N/A	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	5 None	**Latitude, Longitude:**	42.075556, -86.867222

Administrative Information

Investigator In Charge (IIC):	Mitchell F Gallo	**Adopted Date:**	11/29/2007
Additional Participating Persons:	Thomas L Weber; Federal Aviation Administration; Detroit, MI Mark H Smith; The Boeing Company; Seattle, WA Douglas J Zabawa; Pratt & Whitney; East Hartford, CT Heath Nicholl; Kalitta Air; Ypsilanti, MI Jeff Plantz; United Airlines; Elk Grove Village, IL		
Publish Date:			
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/.		