National Transportation Safety Board
Aviation Incident Final Report

Location:	Midland, TX	**Incident Number:**	FTW02IA027
Date & Time:	11/02/2001, 0734 CST	**Registration:**	N814AW
Aircraft:	Airbus Industrie A319-132	**Aircraft Damage:**	None
Defining Event:		**Injuries:**	89 None
Flight Conducted Under:	Part 121: Air Carrier - Scheduled		

Analysis

The transport airplane was in cruise flight at flight level 390 for 12 minutes when they received an "engine oil filter bypass" fault message on the engine centralized aircraft monitoring (ECAM) system; however, all of the engine parameters remained within limits. Subsequently, the oil pressure indication for the #1 (left) engine rose into the red band and a "high vibration and a thumping sound" was felt and heard. The flight crew then declared an emergency and diverted to another airport. The captain reported that during the landing roll, he moved both throttle levers into reverse, and simultaneously the cockpit and cabin began to fill with smoke. Air traffic controllers reported they observed white smoke emanating from the #1 engine during the landing roll. The captain stopped the airplane on the high-speed taxiway, turned off both engines, and an emergency evacuation ensued. The 1L and 2L doors were operated normally; however, the 1R door jammed when the flight attendant attempted to open it. Examination of the 1R door actuator and slide did not reveal the reason it failed to operate. Examination of the engine revealed that debris contamination of the #3 bearing initiated spallation of the bearing's outer ring raceway. Cyclic loading from the bearing balls passing over the growing raceway spall resulted in extensive fretting of the outer diameter surface of the outer ring, from which a fatigue crack was initiated. High-cycle fatigue progression radially through the outer ring was followed by rapid fracture and subsequent liberation of the outer ring fragments. The debris contamination more than likely came from the high-pressure compressor (HPC) stubshaft coating, which was liberated and entered the #3 bearing area causing it to fracture, and the engine to lose power. Research revealed this was one of five similar occurrences, which was traced down to a change in the manufacture process for the HPC stubshaft coating. The manufacturer has taken actions to alert operators of the existing problem.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this incident to be: the #1 engine's fatigue failure of the #3 bearing due to the manufacturer's inadequate design of the high-pressure compressor stubshaft coating, which resulted in a loss of engine power and an emergency landing.

Findings

Occurrence #1: LOSS OF ENGINE POWER(PARTIAL) - MECH FAILURE/MALF
Phase of Operation: CRUISE - NORMAL

Findings
1. 1 ENGINE
2. (C) TURBINE ASSEMBLY,SHAFT BEARING - FATIGUE
3. (C) MATERIAL DEFECT(INADEQUATE QUALITY OF MATERIAL) - MANUFACTURER
4. (C) TURBINE ASSEMBLY,SHAFT BEARING - FAILURE,TOTAL

Occurrence #2: FORCED LANDING
Phase of Operation: DESCENT - EMERGENCY

Findings
5. PRECAUTIONARY LANDING - PERFORMED - FLIGHTCREW

Factual Information

HISTORY OF FLIGHT

On November 2, 2001, at 0734 central standard time, an Airbus Industrie A319-132 transport airplane, N814AW, operating as America West Airlines flight 786, experienced an engine anomaly while in cruise flight and diverted to the Midland International Airport (MAF), Midland, Texas. The captain, who held an airline transport pilot certificate, the first officer, who also held an airline transport pilot certificate, three cabin attendants, and 84 passengers were not injured. The airplane was registered to International Lease Finance Corporation of Los Angeles, California, and operated by America West Airlines of Phoenix, Arizona. Visual meteorological conditions prevailed, and an instrument flight rules (IFR) flight plan was filed for the 14 Code of Federal Regulations Part 121 scheduled passenger flight. The flight originated from the George Bush Intercontinental Airport (IAH), Houston, Texas, at 0610, and was destined for the Phoenix Sky Harbor International Airport (PHX), Phoenix.

According to the captain and first officer, the flight departed IAH and climbed to flight level 390. The flight had been in cruise at flight level 390 for 12 minutes when the flight crew received an "engine oil filter bypass" fault message on the electronic centralized aircraft monitoring (ECAM) system; however, all of the engine parameters remained within limits. The flight crew informed maintenance control of the indication, and decided that if the engine should develop further problems the flight would land at the nearest airport, which was MAF. As a precaution, the flight descended to flight level 350 and obtained the current ATIS (automated terminal information system) information at MAF. Subsequently, the oil pressure indication for the #1 (left) engine rose into the red band and a "high vibration and a thumping sound" was felt and heard. They stated that they did not detect any smoke or odor in the cockpit. The first officer referenced the quick reference handbook (QRH) and completed the "high engine vibration checklist." In accordance with the checklist, the captain moved the thrust lever for the #1 engine to the idle position.

The flight crew then declared an emergency and diverted to MAF. When the flight crew notified the cabin crew of their action to divert, the cabin crew reported that there was a "thin film" of visible, odorless smoke in the area of the forward galley between the first class cabin and the cockpit. The flight crew then donned their oxygen masks. The captain reported that during the landing roll, on runway 16R, he moved both throttle levers into reverse and, simultaneously, the cockpit and cabin began to fill with smoke. The cabin attendants reported that during the landing roll the cabin began to fill with a "heavier" white smoke. The MAF air traffic control tower personnel added that, during the landing roll they observed white smoke emanating from the #1 engine. The captain stopped the airplane on the high speed taxiway, shut-down both engines, and an emergency evacuation ensued.

According to the flight attendants (FA), the #1 and #2 FAs were seated on the forward jump seat (forward of the first class cabin). The captain signaled to evacuate, both FAs got up, and the #1 FA proceeded to the 1L door and the #2 FA proceeded to the 1R door. The 1L door opened and the slide deployed and inflated. The #2 FA reported that she pulled the 1R door handle up and felt the power assist begin to open the door. The slide cover opened and she could see the slide. The door opened approximately 12 inches and then stopped moving. The #2 FA then directed the passengers to exit through the 1L door. The #3 FA was seated on the aft jump seat. When the captain signaled the evacuation, she proceeded to the 2L door, pulled

the door handle up, and the door began to open. The power assist was not as powerful as she expected, and she had to manually push the door open to engage the gust lock. The slide deployed and inflated, and passengers exited. The 2R door was not opened and the #3 FA reported that due to a low number of passengers, flow through the 2L door was good. There were no injuries during the evacuation.

Prior to vacating the airplane, the captain observed the 1R door 3/4 open and the slide "partially out of the bustle." He stated that he then pushed the door "pretty hard," and the door then moved to the fully open position. The evacuation slide deployed and inflated. Maintenance personnel removed the slides and the airplane was towed to a hangar at the airport.

PERSONNEL INFORMATION

The captain held an airline transport pilot certificate and was type rated in the Airbus 319/320, Boeing 737, and the Swearingen 227. According to the NTSB Pilot/Operator Aircraft Accident Report Form, which was completed by America West Airlines, the captain had accumulated a total of 15,000 hours, of which 800 hours were in the A319. He held an FAA first-class medical certificate, with no limitations or waivers, which was issued on May 21, 2001.

The first officer held an airline transport pilot certificate and was type rated in the BA-3100. According to the NTSB Pilot/Operator Aircraft Accident Report Form, the first officer had accumulated a total of 4,800 hours, of which 1,000 were in the A319.

The three cabin attendants were based in Phoenix.

AIRCRAFT INFORMATION

The airplane was delivered to America West Airlines new, and was registered on July 27, 2000. It is equipped with two International Aero Engine Corporation (IAE) 2524-A5 engines, which are rated at 24,000lbs of thrust each. America West configured the airplane with 124 passenger seats and six crew seats. A review of maintenance records revealed no pertinent entries relating to the #1 engine's loss of power. On October 18th, 2001, the last "A" check was performed, during which all of the magnetic chip detectors (MCD) were reported to be clean.

The airframe and engines had accumulated a total of 4,798 hours. The #1 engine (serial number V10778) had accumulated a total of 1,916 cycles.

The IAE series of engines was developed through a consortium of four major engine manufacturers consisting of Pratt & Whitney, Rolls-Royce, Japanese Aero Engines Corporation, and MTU Aero Engines. The IAE 2524-A5 engine is an axial flow, two-shaft engine that incorporates a 4-stage low-pressure compressor (LPC), a 10-stage high-pressure compressor (HPC), a 2-stage high-pressure turbine (HPT), and a 5-stage low-pressure turbine (LPT).

AERODROME INFORMATION

MAF is located at 31 degrees 56.552 minutes north latitude and 102 degrees 12.115 minutes west longitude, at an elevation of 2,871 feet msl. The airport has two parallel runways oriented north-south, one runway oriented east-west, and one runway oriented northeast-southwest. Runway 16R (asphalt) is 9,501 feet long and 150 feet wide.

METEOROLOGICAL INFORMATION

At 0753, the weather observation facility at MAF reported the following weather conditions: clear skies, visibility 10 statute miles, wind from 230 degrees at 8 knots, temperature 17 degrees Celsius, dew point 12 degrees Celsius, and an altimeter setting of 30.06 inches of mercury.

FLIGHT RECORDER INFORMATION

The airplane was equipped with an Allied Signal Solid State Digital Flight Data Recorder (SSDFDR), serial number 5846. The recorder was sent to the NTSB's Vehicle Recorder Laboratory in Washington, DC, where it was found to be in good condition. The recorded data were extracted normally from the recorder and plotted for the entire engine event.

TESTS AND RESEARCH

Initial examination of the airplane and the #1 engine did not reveal evidence of an uncontained engine failure or fire; however, an oil film was observed on the exterior of the #1 engine cowling and along the fuselage. The scavenge oil filter and #1 engine's MCDs contained large quantities of metal particles. The oil pressure filter had been imploded and was covered with metal particles. The engine was then shipped to IAE's Pratt & Whitney facility located in Cheshire, Connecticut, for further examination.

The engine was disassembled by IAE/Pratt & Whitney personnel, under the supervision of the NTSB Investigator-In-Charge (IIC). The engine's nose cone fairing and fan blades were covered with a film of oil; however, displayed no damage. A boroscope was used to examine the front bearing compartment (FBC), and it was discovered that the #3 bearing was fractured. A section of the #3 bearing race was observed lying on the bottom of the FBC. The LPT shaft could not be removed, so the #1 bearing support housing was disassembled and the HPT stubshaft was removed to facilitate further examination.

Following disassembly, sections of the #3 bearing were observed in the #2 bearing support housing. The #2 bearing support housing was then disassembled and it was noted that the hydraulic seal runner had fused to the LPT shaft, therefore preventing its removal from the FBC. The HPC section's shrouds and inner seals displayed damage, consistent with secondary damage from a rearward shift of the HPC rotor. The rotor paths displayed evidence of contact with their respective HPC blades. The HPC contained metal particles, consistent with that from the FBC. The HPC vanes and rotor exhibited damage, typical of debris originating from the FBC. The nozzle guide vane (NGV) and diffuser did not exhibit any damage.

The HPT blade tips were melted and curled. The LPT section contained metal particles. The main oil pressure pump, scavenge pump and air cooled oil cooler were intact; however, displayed damage consistent with metal particles from the #3 bearing. The FBC parts, including the #3 bearing and HPC stubshaft were further examined by personnel at IAE's Pratt & Whitney Materials Laboratory.

The #3 bearing's outer race fractured into 14 pieces. The outer diameter surface contained a thumbnail appearance and major arrest lines, consistent with fatigue. According to the metallurgists examining the failed components, the #3 bearing outer ring failed as a result of "high cycle fatigue that progressed through the ring thickness from a primary origin on the outer diameter surface associated with severe fretting between the [bearing's] outer ring and the [bearing] housing." An area of spalling up to 1.5 inches in length was noted on the outer ring's inside diameter raceway. The exact location of the spalling area's origin could not be determined due to secondary damage; however, it was noted that the spall progression was in

the rolling direction. The area of outside diameter fretting coincided with the same position of the inside diameter's spalling.

The #3 bearing's cage displayed several side fractures and deformation of the side rails and ball pockets. The 20 bearing balls displayed varying degrees of flat areas, consistent with a sliding motion. The inner ring exhibited damage to its raceways and lands, with evidence of ball and cage sliding. The damage to the cage, balls, and inner ring is consistent with secondary damage. Metallographic examination of the bearing balls and the bearing outer ring revealed a "microstructure that was typical of properly processed PWA 793 bearing steel. The general microstructure, porosity, and carbide segregation were within the acceptable limits" specified by the manufacturer's requirements. Hardness tests were conducted on the bearing balls and the bearing's outer ring. The hardness test results revealed the components met the manufacturer's specifications.

Visual examination of the HPC tungsten carbide coated stubshaft exhibited regions of fretting and coating recession at the aft and fore edges of the bevel gear contact area between the axial oil-slot witness marks. Scanning electron microscope examination of the HPC stubshaft hardface coating that coincided with the #3 bearing-feeding oil slots, revealed "several regions containing clusters of 'pits' 0.001 inch (nominal) and larger in diameter. The majority of the pits appeared to be relatively shallow, irregularly shaped 'pock marks' with more severely distressed areas showing edge crumbling, micro-cracking, and pullout features. Regions surrounding the 'pits' generally appeared friable and loosely bonded to the surface." Based on the quantity, size, and shape of the HPC stubshaft's coating surface discontinuities, the manufacturer's metallurgical report opined that "released carbide particulate from the hardface coating may have been a route of bearing contamination and subsequent outer ring raceway spall initiation from debris damage." It should be noted that traces of the HPC stubshaft coating was found in the oil jets adjacent to the HPC stubshaft.

The 1R door actuator was examined at the Barfield, Inc, Miami, Florida, under supervision of an NTSB investigator. No anomalies or malfunctions were found. The 1R evacuation slide was examined and overhauled at Goodrich Corporation, Ontario, California. No anomalies were noted. On December 8, 2001, approximately one month after the incident, maintenance records revealed that the 1R door was checked for proper movement, with no hard points. The associated maintenance entry read, "Ops normal."

ADDITIONAL INFORMATION

Research conducted by IAE revealed four other engines had experienced a fracture of the #3 bearing, and similar secondary damage. On all of the researched engines, it was noted that the HPC stubshaft coating displayed fretting and coating recession on the fore and aft edges of the bevel gear oil feed slot witness marks similar to that noted on engine serial number V10778 (this incident's engine). All of these engines were within the engine serial number range V10600-V10990.

Originally, there were two approved hardface coatings for the HPC stubshaft; 1. Low-energy plasma spray, and 2. High-energy plasma spray. HPC stubshafts were manufactured with high-energy plasma coatings up until engine serial number V10599. At engine serial number 10600, the low-energy plasma spray was utilized during the HPC stubshaft manufacturing process, which was the same process used during the manufacture of this incident's stubshaft. At engine serial number V109901 a material improvement was introduced to the low-energy

plasma coating (fine powder was added to the low-energy plasma spray), which raised it to the same standard as the high-energy plasma spray. At engine serial number V11304, HPC stubshafts were again manufactured using the original high-energy plasma spray coatings. Subsequently, IAE discontinued the use of low-energy plasma spray.

On November 30, 2001, IAE sent an official message to all of their field service representatives, which alerted them of events where the #3 bearing has failed. The message stated: "Recent events have occurred that were the result of debris ingestion into the bearing outer raceway that have caused spalling resulting in outer bearing race fractures." The message alerted the representatives that during future inspections, and any work that permits access to the FBC area, close observation of the front bearing case bevel gears, HPC stubshaft, and the #3 bearing compartment should be undertaken. Furthermore, the message indicated that technical services should be advised of abnormalities in the front bearing case, chips on any of the magnetic chip detectors, or abnormalities discovered during an engine filter oil analysis.

On October 10, 2002, IAE issued an All Operator's Wire (AOW 1064) to all V2500 operators. The wire informed the operators of the #3 bearing failures and history of the HPC stubshaft hardface coating. The message recommended that the HPC stubshaft coating be replaced at the next shop visit. It should be noted that AOW 1064 revision 3, dated May 12, 2003, included the examination of all HPC stubshafts with low-energy plasma hardface coatings.

Pilot Information

Certificate:	Airline Transport; Flight Instructor; Commercial	**Age:**	45, 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:**	Yes
Instructor Rating(s):	Airplane Single-engine	**Toxicology Performed:**	No
Medical Certification:	Class 1 Valid Medical--no waivers/lim.	**Last FAA Medical Exam:**	05/21/2000
Occupational Pilot:		**Last Flight Review or Equivalent:**	
Flight Time:	15000 hours (Total, all aircraft), 800 hours (Total, this make and model)		

Co-Pilot Information

Certificate:	Airline Transport; Flight Instructor; Commercial	**Age:**	30, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	None	**Restraint Used:**	Seatbelt, Shoulder harness
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	Airplane Single-engine; Instrument Airplane	**Toxicology Performed:**	No
Medical Certification:	Class 1 Valid Medical--no waivers/lim.	**Last FAA Medical Exam:**	05/21/2001
Occupational Pilot:		**Last Flight Review or Equivalent:**	
Flight Time:	4800 hours (Total, all aircraft), 1000 hours (Total, this make and model)		

Aircraft and Owner/Operator Information

Aircraft Make:	Airbus Industrie	**Registration:**	N814AW
Model/Series:	A319-132	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	No
Airworthiness Certificate:	Transport	**Serial Number:**	1281
Landing Gear Type:	Retractable - Tricycle	**Seats:**	130
Date/Type of Last Inspection:	10/18/2001, Continuous Airworthiness	**Certified Max Gross Wt.:**	150000 lbs
Time Since Last Inspection:		**Engines:**	2 Turbo Fan
Airframe Total Time:	4798 Hours at time of accident	**Engine Manufacturer:**	International Aero Engines
ELT:		**Engine Model/Series:**	IAE-2524-A5
Registered Owner:	International Lease Finance Corporation	**Rated Power:**	24000 lbs
Operator:	America West Airlines Inc.	**Operating Certificate(s) Held:**	Flag carrier (121)
Operator Does Business As:	America West	**Operator Designator Code:**	AWXA

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual Conditions	**Condition of Light:**	Day
Observation Facility, Elevation:	MAF, 2871 ft msl	**Distance from Accident Site:**	
Observation Time:	0753 CST	**Direction from Accident Site:**	
Lowest Cloud Condition:	Clear	**Visibility**	10 Miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	8 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	230°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30.06 inches Hg	**Temperature/Dew Point:**	17°C / 12°C
Precipitation and Obscuration:			
Departure Point:	Houston, TX (IAH)	**Type of Flight Plan Filed:**	IFR
Destination:	Phoenix, AZ (PHX)	**Type of Clearance:**	VFR
Departure Time:	0610 CST	**Type of Airspace:**	Class C

Airport Information

Airport:	Midland International (MAF)	**Runway Surface Type:**	Asphalt
Airport Elevation:	2871 ft	**Runway Surface Condition:**	Dry
Runway Used:	16R	**IFR Approach:**	ILS
Runway Length/Width:	9501 ft / 150 ft	**VFR Approach/Landing:**	Precautionary Landing

Wreckage and Impact Information

Crew Injuries:	5 None	**Aircraft Damage:**	None
Passenger Injuries:	84 None	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	89 None	**Latitude, Longitude:**	31.942500, -102.201944

Administrative Information

Investigator In Charge (IIC):	Jason A Ragogna	**Report Date:**	12/03/2004
Additional Participating Persons:	Steven Miller; Federal Aviation Administration; Lubbock, TX Sylvain Ladiesse; Bureau Enquetes - Accidents (BEA) Thierry Thoreau; Airbus Industrie Michael L Young; International Aero Engines; East Hartford, CT Jack Drake; America West Airlines; Phoenix, AZ Mark Solper; Airline Pilots Association		
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/.		