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POWERPLANTS GROUP CHAIRMAN'S FACTUAL REPORT

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NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF AVIATION SAFETY
WASHINGTON, D.C. 20594

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POWERPLANTS GROUP CHAIRMAN'S FACTUAL REPORT

NTSB ID No. DCA97MA058

A: ACCIDENT

Location: Nimitz Hill, Guam

Date: August 6, 1997

Time: 0142 local Guam time

Aircraft: Boeing 747-3B5, HL-7468, Korean Air, Flight No. 801

B: POWERPLANTS GROUP

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C: SUMMARY

On August 6, 1997, at 0142 local Guam time, Korean Air flight No. 801, a Boeing 747-3B5 airplane, registered in Korea as HL-7468, crashed into hilly terrain at Nimitz Hill about 3 miles from the Guam Airport, while on final approach to runway 6 Left. The airplane was equipped with four Pratt & Whitney (P&W) JT9D-7R4G2 turbofan engines. The airplane was operating on an instrument flight rules (IFR) flight plan under the provisions of Title 14 Code of

Federal Regulations (CFR) Part 129 as a regularly scheduled, international passenger flight from Seoul, Korea to Guam.

The Powerplants Group commenced its examination of the crash site and engines on August 8, 1997. All four of the engines were found separated from the airplane. The No. 1 engine was located about 475 feet past the engine's initial ground contact and about 1,300 feet from the main wreckage site. The other three engines were all located at the main wreckage site. All of the engines had damage to the fan blades with the tips and leading edges bent away from the direction of rotation, and vegetation and dirt ingested into the fans and low pressure compressors (LPCs). There were no indications of any uncontainments, case ruptures, in-flight fires, or postimpact fire damage on any of the four engines. The engines were not disassembled. The Powerplants Group completed its on-site activities on August 11, 1997.

D: DETAILS OF INVESTIGATION

1.0 Engine information

1.1 Engine description

The JT9D-7R4G2 engine is a dual-spool, axial flow, high bypass turbofan that features a 1-stage fan, 4-stage LPC, 11-stage high pressure compressor (HPC), annular combustor, 2-stage high pressure turbine (HPT), and a 4-stage low pressure turbine (LPT). The JT9D-7R4G2 engine has a takeoff thrust rating of 54,750 pounds, flat-rated to 87°F.[1]

1.2 Engine history

The installed position of each of the engines, serial number (SN), total time (TT), total cycles (TC), time since overhaul (TSO), cycles since overhaul (CSO), time since last shop visit (TSLV), cycles since last shop visit (CSLV), time since installation (TSI), cycles since installation (CSI), date of installation, and last repair station are as follows:

[1] Flat-rated to a specific temperature indicates the engine will be capable of attaining the rated thrust level up to the specified temperature.

Position	1	2	3	4
SN	725312	715141	725305	715243
TT (hours)	26,014	36,611	25,904	33,889
TC (cycles)	4,699	6,137	4,383	5,701
TSO (hours)	4,121	3,948	7,997	3,893
CSO (cycles)	1,206	1,170	1,396	1,146
TSLV (hours)	4,121	3,948	444	3,893
CSLV (cycles)	1,206	1,170	182	1,146
TSI (hours)	4,121	3,948	444	3,893
CSI (cycles)	1,206	1,170	182	1,146
Date installed	4/11/96	4/29/96	6/11/97	5/7/96
Last repair station	Korean Air	Korean Air	Korean Air	Korean Air

2.0 Engine No. 1, SN 725312

The engine was laying on its left side[2] with the front compressor front hub (fan hub) embedded into a small mound of dirt about 475 feet past the No. 1 engine's initial contact with the ground. The inlet, fan exit case, cowling, gear box, thrust reverser, exhaust duct, exhaust plug, and pylon were separated from the engine. These items were found between the location of the initial ground scar and the location of the No. 1 engine. There was a 270° section of the fan exit case containing the front engine mount and a portion of the turbine exhaust case containing the rear engine mount and pylon bulkhead that were found in separate locations beyond the No. 1 engine. There was no indication of any uncontainments or case ruptures. There was no damage due to fire. The No. 1 engine was identified by cross-referencing the serial numbers (SNs) that were found on the fuel flow transmitter and gear box data plate to Korean Air engine records.

The fan hub was intact. Of the 18 fan blades that were visible, 5 fan blades were full length. The remaining 13 fan blades that were visible were fractured across the airfoil between 6 and 17 inches above the blade root platform. The leading edges of the fan blades had numerous nicks, dents, and bends. The fan blades were packed with dirt and vegetation. All of the visible full- and partial-length fan blades were bent away from the direction of engine rotation. Numerous broken fan blades, full length fan exit guide vanes, and pieces of cowling and the thrust reverser cascades were found along the No. 1 engine's wreckage path from the location of the initial ground scar to the location of the engine.

A piece of fan blade tip, which was fractured transversely across the airfoil about 9 inches inboard from the tip and was curled, was found along the flight path prior to the No. 1 engine's initial ground contact, but just past some trees that had been struck by the No. 1 engine. The fracture surface of the piece of fan blade did not have any indications of fatigue and appeared to be typical of an overload type of fracture that originated from a tear at the leading edge.

[2] All locations on the engine, or positions or directions as referenced to the clock, are as viewed from the rear looking forward, unless otherwise specified.

The first 3 stages of the low pressure compressor (LPC) were visible. The compressor blades were packed with dirt and vegetation, and were bent away from the direction of rotation.

The fan case was intact, but was separated from the engine and was found along the No. 1 engine's wreckage path. The fan rubstrip was rubbed, but the axial skewed groove (ASG) pockets were still visible. The rub strip was gouged at 8 o'clock.

The turbine exhaust case had dirt and vegetation packed against the 6th stage turbine blades from 10 to 3 o'clock. There was a 7-inch deep, semi-circular shaped hole in the ground, which was the same size as the rear of the turbine exhaust case, directly adjacent to the back of the engine. The No. 4 bearing housing support was fractured circumferentially just outboard of the bolt circle and pushed forward. The four turbine exhaust struts at the bottom of the turbine exhaust case were buckled. There was approximately a 210° arc of the 6th stage turbine blades that were visible. All of the visible blades were straight and full length. There was no metal spatter on the visible turbine blade airfoils. The 6th stage turbine blade tips had a powdery gray material on the underside of the shrouds.

3.0 Engine No. 2, SN 715141

The engine was laying on its right side. The inlet, fan exit case, cowling, thrust reverser, exhaust duct, exhaust plug, and pylon were separated from the engine. All of these items were found in the same area where the No. 2 engine was found. There was no indication of any uncontainments or case ruptures. There was no damage due to fire. The No. 2 engine was identified by cross-referencing the SN that was found on the engine fuel control to Korean Air engine records.

The fan hub was intact. All of the fan blades were in place. There were 16 fan blades that varied in length from full length to being fractured across the airfoil about 17 inches from the blade root platform. The leading edges of the fan blades had numerous nicks, dents, and bends. The fan blades were bent away from the direction of engine rotation. The full- and partial- length fan blades were packed with dirt and vegetation. The remaining fan blades were fractured transversely across the airfoil directly adjacent to the blade root platform.

The first 3 stages of the LPC were visible. The compressor blades were packed with dirt and vegetation, and were bent away from the direction of rotation.

The fan case was on the engine, but was loose and at an angle, 2 feet and 6 feet aft of its normal position at 12 and 6 o'clock, respectively. The fan exit case had a 60° arc at 12 o'clock that was separated and was found about 10 feet away from the engine. The front engine mount and pylon remained attached to the separated portion of the fan exit case.

The 6th stage turbine blades had a 90° arc of blades that had the tips fractured about 2 inches inboard of the shroud. The remainder of the 6th stage turbine blades were in place and had no rotational damage. There was no metal spatter on the turbine blade airfoils.

4.0 Engine No. 3, SN 725305

The No. 3 engine was laying on its right side. The inlet, exhaust duct, exhaust plug, and pylon were separated from the engine. These items, with the exception of the exhaust plug, were found near the engine. Two exhaust plugs were found along the side of the access road near the site of the initial ground contact of the landing gear. There was no indication of any uncontainments or case ruptures. There was no damage due to fire. The No. 3 engine was identified by cross-referencing the SN that was found on the constant speed drive and the engine SN that was marked on the fan hub to Korean Air engine records.

The fan hub was intact. All of the fan blades were in place in the hub and were full length. The fan blade tips were curled slightly away from the direction of rotation. The leading edges of the fan blades had numerous nicks, dents, and bends. The fan blades were packed with dirt and vegetation. The blade airfoils were bent rearward between 4 and 8 o'clock. The rear edge of the fan exit cowling was pushed forward from 5 to 9 o'clock.

The turbine exhaust case had dirt and vegetation packed against the 6th stage turbine blades such that only a 90° arc of the blades were visible. All of the visible turbine blades were intact and full length. There was no metal spatter on any of the turbine blades, and the blades had a gray powdery material on the convex side of the airfoils.

5.0 Engine No. 4, SN 715243

The No. 4 engine was laying on its right side. The inlet, fan case, thrust reverser, cowling, exhaust duct, and exhaust plug were separated from the engine. These items with the exception of the exhaust plug were located near the engine. Two exhaust plugs were found along the side of the access road near the site of the initial ground contact of the landing gear. There was no indication of any uncontainments or case ruptures. There was no fire damage to the engine. The No. 4 engine was identified by cross-referencing the fan hub SN to Korean Air engine records.

The fan hub was intact. All of the fan blades were in place, but were fractured across the airfoil at various lengths from just above the blade root platform to 17 inches above the blade root platform. The ends of the longer fan blades were bent away from the direction of engine rotation. The leading edges of the fan blades had numerous nicks, dents, and bends. There was an approximately 4-inch diameter piece of tree or branch wedged between the back of the fan hub and the 1st stage stator at 12 o'clock.

The fan case was separated from the engine, but was located near the engine. The fan case was ovalized, but was intact. The fan rubstrip material was missing from the case almost all the way around the circumference of the case. The rubstrip material remained in an area from about 5 to 7 o'clock, but was rubbed down almost to the bottom of the ASG pockets.

The No. 1 bearing support was fractured circumferentially just inboard of the outer bolt circle. There were two ball bearings from the No. 1 bearing that were found next to

the fractured bearing support. The ball bearings had some minor surface corrosion, but did not have any apparent rotational distress.

The first 3 stages of the LPC were visible. The compressor blades were packed with dirt and vegetation, and were bent away from the direction of rotation.

The 6th stage turbine blades were intact and straight. There was no metal spatter on the turbine blade airfoils.

6.0 Thrust reversers

6.1 No. 3 engine reverser

The No. 3 engine's thrust reverser system remained attached to the engine. The thrust reverser actuator jackscrew assemblies had the jackscrew drives at the forward end of the jackscrews. The reverser cascades were packed with dirt and vegetation almost completely around except for an area from 10 to 12 o'clock that was free of any dirt or vegetation and that did not have any dirt impingement on the cascade turning vanes. The thrust reverser blocker doors that were visible were in the retracted position.

6.2 Other engines' reversers

The reversers from the other three engines had all separated from the engines. There were numerous reverser cascades, blocker doors, and actuators found along the path of the initial ground contact of the No. 1 engine and the location where the No. 1 engine was found. There were also reverser cascades, blocker doors, and actuators found in the immediate vicinity of the No. 2 and 4 engines. None of the cascades had any dirt impingement on the turning vanes. All of the thrust reverser actuator jackscrew assemblies had the jackscrew drives at the forward end of the jackscrews.

7.0 Auxiliary power unit

The auxiliary power unit (APU) was intact, but the bottom part of the exhaust case was dented inward. There were no case ruptures or uncontainments on the APU. The turbine blades were intact. The APU was hanging from the forward mount. The rear mount was intact, but the bracket that supports the rear mount was pulled out of the fuselage structure. There was no fire damage to the APU.

8.0 Engine wreckage distribution

The four engines were separated from the wings of the airplane. The No. 1 engine was located about 475 feet past a ground scar and about 900 feet from the tail section of the airplane and other three engines. The ground scar consisted of a 13 feet 6 inch long x 7 feet wide gouge that was in line with a 25 feet long x 3 feet wide gouge that was 30 feet past the first gouge. The magnetic heading of the two gouges was 062° magnetic. Vegetation that was

directly in front of the start of the initial ground contact of the No. 1 engine was black and wilted. The No. 2 engine was located to the left of the fuselage and tail between the left and right wings. The No. 3 engine was located under the right horizontal stabilizer. The No. 4 engine was located behind and slightly to the right of the right horizontal stabilizer. The engine wreckage diagram that shows the location of the engines in relation to the airplane wreckage is attached, Attachment 1.

9.0 Digital flight data recorder engine parameters

The digital flight data recorder (DFDR) recorded each engine's exhaust pressure ratio (EPR).[3] The DFDR recorded the EPR data for each engine once every 4 seconds. The DFDR data show that all four engines were running and consistently matched during the final 5 minutes of the flight. For most of the final 5 minutes, the engine EPRs were at 1.00. At 50 seconds before impact, the engine EPRs increased from 1.00 to 1.10, and then decreased and stabilized at 1.04. At 7 seconds before impact, the engine EPRs began increasing. The maximum recorded EPR was 1.346 on the No. 3 engine 2 seconds before impact. A copy of the DFDR recorded engine EPR data is attached, Attachment 2. For more detailed information regarding the DFDR data, refer to the Flight Data Recorder Group Chairman's Factual Report.

10.0 Cockpit engine instrumentation

The cockpit engine instrumentation indications were documented by the Systems Group. EPR indications were off scale for engines No. 1, 2, and 4 and 1.0 for engine No. 3. The N1[4] indications were all zero. The exhaust gas temperature (EGT) indications for engines No. 1, 2, 3, and 4 were off scale, 530, 440, and zero, respectively.[5] The fuel flow indications for engines No. 1, 2, 3, and 4 were 5.0, 2.4, 1.0, and 4.2, respectively.[6] The power levers for all four engines were full forward and the levers for No. 3 and 4 engines were bent. For more detailed information regarding the DFDR data, refer to the Systems Group Chairman's Factual Report.

Gordon J. Hookey
Powerplants Group Chairman
10/20/97

[3]Engine pressure ratio (EPR) is a measurement of engine power output as a ratio of the total pressure of the gases in the exhaust pipe (P_{t7}) divided by the total pressure of the air entering the engine inlet (P_{t2}). EPR is equal to P_{t7}/P_{t2}.
[4] N1 is the low pressure compressor rotor speed.
[5] Exhaust gas temperature is indicated in degrees Celsius. The EGT redline limit is 650°C.
[6] Fuel flow is indicated in units of thousands of pounds per hour.