AI2013-1

# AIRCRAFT SERIOUS INCIDENT INVESTIGATION REPORT

**ANA WINGS CO., LTD.**
**J A 8 0 5 K**

**February 22, 2013**

Japan Transport Safety Board

The objective of the investigation conducted by the Japan Transport Safety Board in accordance with the Act for Establishment of the Japan Transport Safety Board (and with Annex 13 to the Convention on International Civil Aviation) is to prevent future accidents and incidents. It is not the purpose of the investigation to apportion blame or liability.

Norihiro Goto
Chairman,
Japan Transport Safety Board

Note:

This report is a translation of the Japanese original investigation report. The text in Japanese shall prevail in the interpretation of the report.

# AIRCRAFT SERIOUS INCIDENT INVESTIGATION REPORT

# ENGINE INTERIOR DAMAGE
# ANA WINGS CO., LTD.
# BOMBARDIER DHC-8-314, JA805K
# 6, 700 FT, SOUTHWEST OF OSAKA INTERNATIONAL AIRPORT, JAPAN
# AT 16:50 LOCAL TIME, JUNE 27, 2011

January 25, 2013

Adopted by the Japan Transport Safety Board

| | |
|---|---|
| Chairman | Norihiro Goto |
| Member | Shinsuke Endoh |
| Member | Toshiyuki Ishikawa |
| Member | Sadao Tamura |
| Member | Yuki Shuto |
| Member | Toshiaki Shinagawa |

## SYNOPSIS

### Summary of the Serious Incident

On June 27 (Monday), 2011, a Bombardier DHC-8-314, registered JA805K, operated by ANA WINGS CO., LTD., took off from Osaka International Airport as the scheduled flight 1613 of ALL NIPPON AIRWAYS CO., LTD*[1]. During its climb through 6,700 feet, a loud noise was heard from the No. 1 engine at 16:50 local time*[2]. The flight crew shut it down due to its power loss and made a turn back. After obtaining priority in air traffic control, it made an uneventful landing at Osaka International Airport.

The post-flight engine inspection found circumferential turbine blade damage in several stages.

On board the airplane were 34 persons, consisting of the pilot in command (PIC), three crewmembers, and 30 passengers. Nobody suffered the injury.

### Probable Causes

In this serious incident, during the airplane's after-takeoff climb, a section of the cooling ring in the combustion chamber of the engine was fractured due to the progress of fatigue cracks, and the fractured piece went downstream to damage the fast-rotating turbine blades and other parts, resulting in the circumferential turbine blade damage on several downstream turbine stages.

*1 ANA WINGS CO., LTD. and ALL NIPPON AIRWAYS CO., LTD (ANA) have a joint transportation contract and the airplane was flown as ANA flight.

*2 Japan Standard Time (JST): UTC + 9hr, unless otherwise stated all times are indicated in JST on a 24-hour clock.

# 1. PROCESS AND PROGRESS OF THE INVESTIGATION

## 1.1 Summary of the Serious Incident

The occurrence covered by this report falls under the category of “Damage of engine (limited to a major damage which occurred inside of the engine) “as stipulated in Clause 6, Article 166-4 of the Ordinance for Enforcement of the Civil Aeronautics Act of Japan and is classified as an airplane serious incident.

On June 27 (Monday), 2011, a Bombardier DHC-8-314, registered JA805K, operated by ANA WINGS CO., LTD., took off from Osaka International Airport as the scheduled flight 1613 of ALL NIPPON AIRWAYS CO., LTD. During its climb through 6,700 feet, a loud noise was heard from the No. 1 engine at 16:50. The flight crew shut it down due to its power loss and made a turn back. After obtaining priority in air traffic control, it made an uneventful landing at Osaka International Airport.

The post-flight engine inspection found circumferential turbine blade damage in several stages.

On board the airplane were 34 persons, consisting of the PIC, three crewmembers, and 30 passengers. Nobody suffered the injury.

## 1.2 Outline of the Incident Investigation

### 1.2.1 Investigation Organization

On June 27, 2011, the Japan Transport Safety Board (JTSB) designated an investigator-in-charge and two investigators to investigate this serious incident.

### 1.2.2 Representative from Foreign Authorities

An accredited representative of Canada, as the State of Design and Manufacture of the airplane and engine, participated in the investigation.

### 1.2.3 Implementation of the Investigation

| | |
|---|---|
| June 28 and 29, 2011 | Airplane examination and interviews |
| July 11, 2011 to February 10, 2012 | Teardown inspection of the engine and inspection of fracture surface |

### 1.2.4 Provision of Factual Information to the Civil Aviation Bureau, Ministry of Land, Infrastructure, Transport and Tourism

On July 22, 2011, the JTSB provided the Civil Aviation Bureau of the Ministry of Land, Infrastructure, Transport and Tourism with factual information regarding damage to inside of the engine.

### 1.2.5 Comments from Parties Relevant to the Cause of the Serious Incident

Comments were invited from parties relevant to the cause of the serious incident.

### 1.2.6 Comments from the Relevant State

Comments on the draft report were invited from the relevant State.

# 2. FACTUAL INFORMATION

## 2.1 History of the Flight

On June 27, 2011, a Bombardier DHC-8-314, registered JA805K, operated by ANA WINGS CO., LTD. (hereinafter referred to as "the Company"), took off from Osaka International Airport as ANA scheduled flight 1613 at 16:46. The circumstances in which this serious incident occurred are summarized below, based on the radar tracks, records of the flight data recorder and cockpit voice recorder as well as statements of the crewmembers:

When the airplane was climbing through 6,700 feet at 16:50, a loud noise was heard from the No.1 engine. The inter-turbine temperature (ITT) exceeded the limit of 950 °C and the engine power decreased. The flight crew shut it down and decided to turn back to the airport. After declaring a state of emergency, the airplane stayed over SHINODA VOR/DME to prepare for approach and made an uneventful landing at the airport at 17:18.

Post-flight engine inspection found the damage of turbine blades on the whole circumference in several stages.

This serious incident occurred at about 16:50, at 6,700 feet, 13 kilometers southwest of the airport (Latitude 34° 42' 16" N, Longitude 135° 19' 48" E).

(See Figure 1: Estimated Flight Route, Photo 2: Around the Exhaust Duct of the Engine)

## 2.2 Injuries to Persons

There were no injuries to the persons aboard the airplane.

## 2.3 Information about Damage to the Airplane

### 2.3.1 Extent of Damage to the Airplane

Minor damage (major damage inside of the engine)

### 2.3.2 Details of Damage to the Engine

Details of damage seen inside of the Engine were as follows:

| | | |
|---|---|---|
| a. | Combustion chamber outer liner | : Partial fracture of cooling ring |
| b. | High pressure turbine (HPT) vanes | : Partial fracture |
| c. | HPT blades | : Total fracture |
| d. | Low pressure turbine (LPT) vanes | : Broken |
| e. | LPT blades | : Total fracture |
| f. | Power turbine (PT) vanes | : Broken |
| g. | PT blades | : Total fracture |

No damage linked to this incident was found on the airplane.

## 2.4 Personnel Information

a. PIC Male, Age 41

| | |
|---|---|
| Airline Transport Pilot Certificate (Airplane) | June15, 2005 |
| Type rating for De Havilland DHC 8 | November 14, 2007 |
| Class 1 Aviation Medical Certificate | |
| Validity | Until November 16, 2011 |

b. First Officer (FO) Male, Age 24

Commercial Pilot Certificate (Airplane) April 18, 2007

Type rating for De Havilland DHC 8 March 12, 2010

Class 1 Aviation Medical Certificate

Validity Until June 17, 2012

## 2.5 Airplane Information

### 2.5.1 Airplane

Type Bombardier DHC-8-314

Serial number and date of manufacture 592 / December 12, 2002

Certificate of airworthiness and validity Tou-23-019 / April 24, 2012

Category of airworthiness Airplane, Transport T

Total flight time and total cycle 13,631 hr 30 min / 20,242 cycles

Flight time since last periodical check (CO3 check on December 27 2010)

787 hr 25 min

(See Figure 2: Three Angle View of Bombardier DHC-8-314, Photo 1: Serious Incident Aircraft)

### 2.5.2 Engines

| | No.1 Engine | No.2 Engine |
|---|---|---|
| Type | Pratt & Whitney Canada PW123B | |
| Serial Number | PCEAR0036 | PCEAR0038 |
| Date of manufacture | August 11, 2001 | December 14, 2001 |
| Total time in service | 13,076 hr 32 min | 12,282 hr 06 min |
| Total cycles in service | 19,818 | 18,783 |

The combustion chamber outer liner and HPT blades logged 3,415 hours and 58 minutes with 4,820 cycles since they were replaced with an overhauled parts, and new parts, respectively.

The engine consists of a two-stage centrifugal compressor, a combustion chamber and turbines. Turbines are three-shaft type with one-stage HPT, one-stage LPT and two-stage PT.

(See Figure 3: Engine Cross Section)

### 2.5.3 Weight and Balance

When the serious incident occurred, the airplane's weight was estimated to have been 16,302 kilograms and the center of gravity (CG) was estimated to have been 30.1% MAC (Mean Aerodynamic Chord), both of which are estimated to have been within the allowable ranges (the maximum takeoff weight of 18,996 kilograms, and the CG range of 17.9% to 40% MAC corresponding to the weight at the time of the serious incident).

## 2.6 Meteorological Information

Regular weather observations at the airport, around the time of this serious incident were as follows:

17:00 Wind direction 230°, Wind velocity 10 kt
Visibility 35 km
Cloud: Amount 1/8, Type Cumulus, Cloud base 2,000 ft
Amount 6/8, Type Stratocumulus, Cloud base 10,000 ft
Temperature 30 °C, Dew point 21 °C
Altimeter setting (QNH) 29.85 inHg

## 2.7 Engine Teardown Inspection

With the cooperation of the Transportation Safety Board of Canada, the JTSB made a teardown inspection and fracture surface inspection at the manufacturer's facility. The inspection revealed details about damage as mentioned in the following sections.

### 2.7.1 Damage on Combustion Chamber

Fatigue cracks in the circumferential and axial directions were found on several locations of cooling ring attached to the combustion chamber outer liner. A missing section (approximately 63 x13 millimeters) as a result of crack development was confirmed.

(See Photo 3: Combustion Chamber Outer Liner)

### 2.7.2 Damage to HPT Area

The HPT vane ring at the combustion chamber outlet showed impact damages at the trailing edge (chip-offs and impact marks).

All 38 HPT blades were fractured just above the platform. Fracture surface indicated blade fracture due to impact damage. One blade exhibited a small fatigue crack on the fracture surface: a crack with a length of approximately 2.5 millimeters near the mid section of the pressure side of the aerofoil. Judging from the fracture surfaces of other blades indicative of impact fracture, it was confirmed that this blade had been fractured due to impact, too.

(See Photo 4: HPT Disk)

### 2.7.3 Condition of Damage to LPT Area

All the 53 LPT blades showed mechanical degradation at the tips. It was confirmed to have been caused by impact damage.

### 2.7.4 Condition of Damage to PT Area

The first and second stage PT vanes exhibited damage. All the PT blades (66 blades on the first stage and 71 blades on the second stage) were fractured. On the remaining section of the PT blades (on the root side) exhibited impact marks caused by shattered pieces from upstream. Judging from the condition of fracture surface, it was confirmed that the blades had been broken due to impact damage.

Some intershaft rubbing was observed.

### 2.7.5 Condition of Fuel Nozzles

The fuel nozzle functions were examined in accordance with the maintenance manual. It was confirmed that the fuel nozzles had no functional anomaly.

## 2.8 Information about Design Criteria for the Airplane

### 2.8.1 Design Criteria for One Engine Shutdown for the Airplane

The airplane meets the aircraft design criteria (JCAB Airworthiness Standards) which requires the aircraft performance for a safe landing in case of one engine out.

### 2.8.2 Design Criteria Regarding Fracture of Rotor Blades of Engine

The engine meets the criteria in Paragraph 2-6-1, Part VII "Engine," JCAB Airworthiness Standards, which is stipulated as follows:

> *Engine design and construction must minimize the development of an unsafe condition of the engine between overhaul periods. The design of the compressor and turbine rotor cases must provide for the containment of damage to the outside of the cases from rotor blade failure. Energy levels and trajectories of fragments resulting from rotor blade failure that lie outside the compressor and turbine rotor cases must be defined.* (The rest is omitted)

### 2.8.3 Reliability Control for the Same Type of Engines

The engine manufacturer had set the index value for reliability control for the same type of engines as engine in-flight shut down (IFSD) rate at 0.01 time per 1,000 flight hours on a six-month moving average. The manufacturer is required to manage the reliability of the engines involved so that the comprehensive actual operation records (based on the engine data obtained from all users) may be kept below the index value, and if actual values exceeds the index value it must take necessary corrective measures. Meanwhile, the operators are required to continue engine maintenance to stay below the index value.

### 2.8.4 IFSD Rate for the Same Type of Engine

As the engine operational time per year is small at the Company, it set the reliability control index at one time or less a year in its maintenance manual.

In the 12 months before the occurrence of this serious incident, the same type engines experienced IFSD at the Company. Even if this incident had been included, its IFSD rate could have not exceeded the index value.

As far as the reliability control by the manufacturer for the same type of engines is concerned, the actual IFSD rate compiled at the manufacturer had been less than 0.01 times every 1,000 flight hours on a six-month moving average retroactive to 10 years before the occurrence of this serious incident.

# 3. ANALYSIS

## 3.1 Qualification of Flight Crew

The PIC and the FO held both valid airman competence certificates and valid aviation medical certificates.

## 3.2 Airworthiness Certificate

The Airplane had a valid airworthiness certificate and had been maintained and inspected as prescribed.

## 3.3 Relation to Meteorological Conditions

The meteorological conditions at the time of this serious incident had no bearing on the occurrence of this incident.

## 3.4 Damage to the Engine

The damage was contained within the engine case as described in 2.3.2, and it is very unlikely that the engine damage affected the functions of other airplane systems.

In light of the damage descriptions in 2.7 (discovered in the teardown inspection), it is very likely that fatigue cracks in circumferential and axial directions on the cooling ring had formed before the occurrence of this serious incident due to repeated stress in the combustion chamber, and the cracks had grown bigger as time passed, causing the section involved to be broken. As the fracture surface of the bases of the HPT blades indicated the cause of fracture by impact, it is very likely that the missing section of the cooling ring was carried into the HPT area by the combustion gas to strike against the fast-rotating HPT blades or to be caught between the HPT blades and vanes. This generated fractured HPT blades and broken pieces and they further damage the other components leading to the whole circumference. The downstream LPT and PT stages were very likely damaged by broken fragments of the HPT blades and others coming from the upstream.

It could not be determined what had caused the fatigue cracks which led to the missing section of the cooling ring in the combustion chamber.

## 4. PROBABLE CAUSES

In this serious incident, during the airplane's after-takeoff climb, a section of the cooling ring in the combustion chamber of the engine was fractured due to the progress of fatigue cracks, and the fractured piece went downstream to damage the fast-rotating turbine blades and other parts, resulting in the circumferential turbine blade damage on several downstream turbine stages.

# 5. PREVENTIVE ACTIONS

## Preventive actions taken after the occurrence of this serious incident

### 5.1 Measures Taken by the Company

The Company voluntarily carried out engine borescope inspections for seven same models responding to the advice of the engine manufacturer. The inspection found cracks in one of them, in the circumferential direction in the cooling ring of the combustion chamber outer liner and the Company grounded the engine. It was sent to the manufacturer for teardown inspection and the inspection found a similar damage observed in this serious incident.

### 5.2 Measures Taken by the Engine Manufacturer

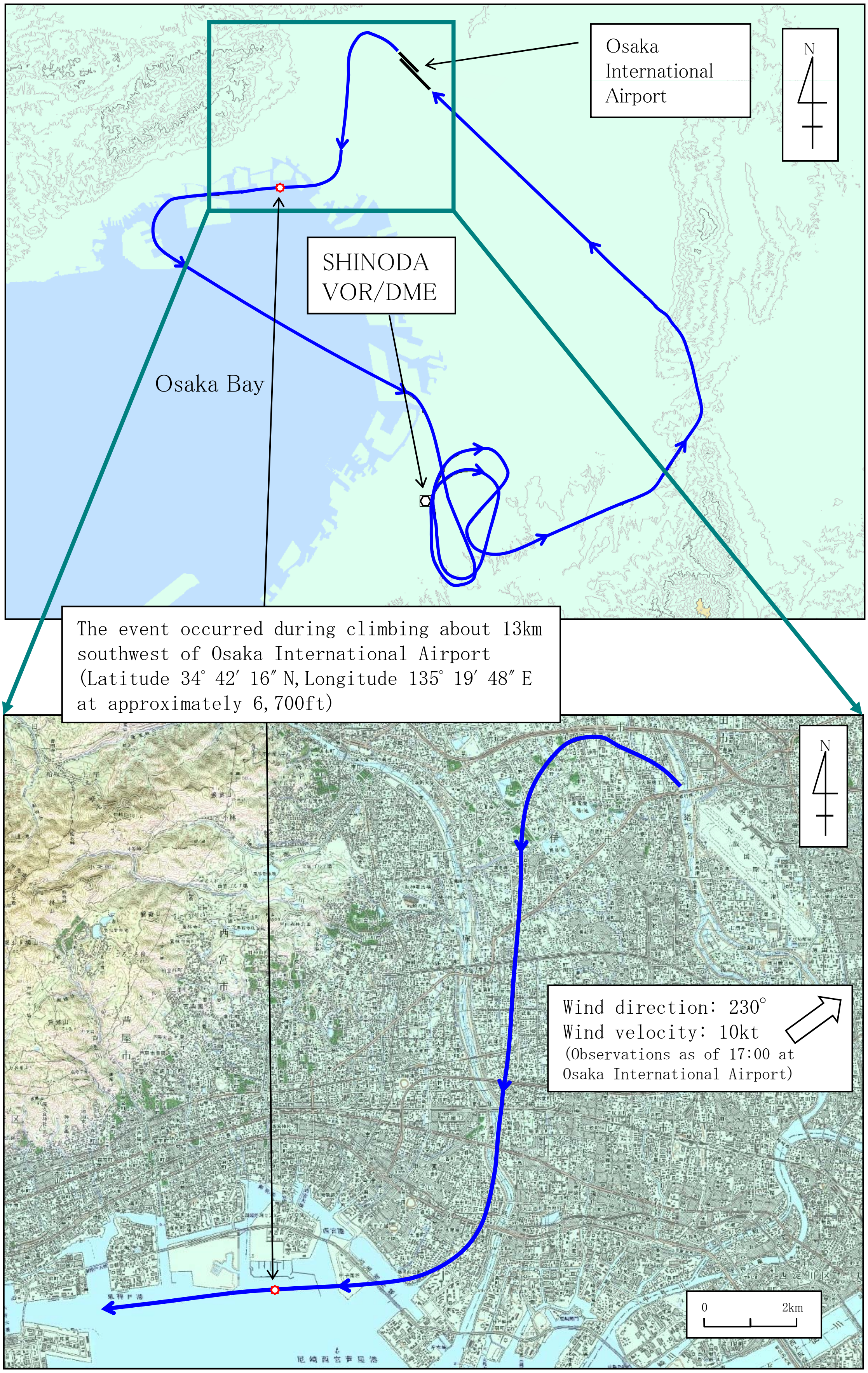
Because the combustion chamber outer liners of the two engines had been repaired in the same period of time, the engine manufacturer started to review the repair process.

The engine manufacturer released a temporary revision of its engine manual, No. 72-106 (effective on April 17, 2012) to insert the permissible crack criteria for cooling rings in the section of engine borescope inspection.

### 5.3 Measures Taken by the Civil Aviation Bureau, the Ministry of Land, Infrastructure, Transport and Tourism

The Civil Aviation Bureau, with the reception of the aviation safety information as described in 1.2.4, urged domestic operators (except the Company) using the same type of airplanes to make borescope inspections. The inspection found no additional crack cases in the circumferential direction in the combustion chamber cooling ring.

Figure 1　Estimated Flight Route




1:50,000 scale Topographic Map by The Geospatial Information Authority of Japan

## Figure 2 Three Angle View of Bombardier DHC-8-314

Unit : m

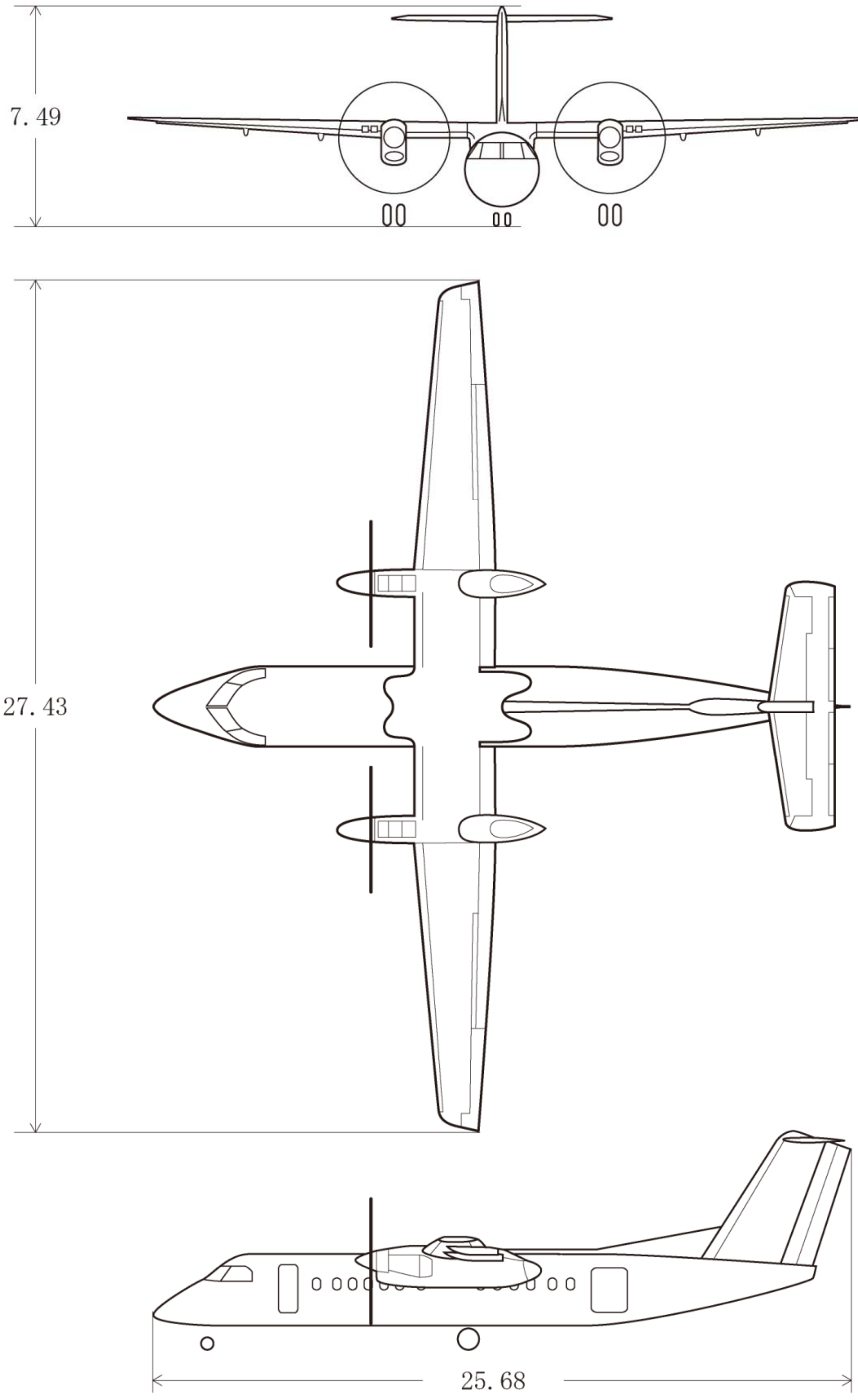
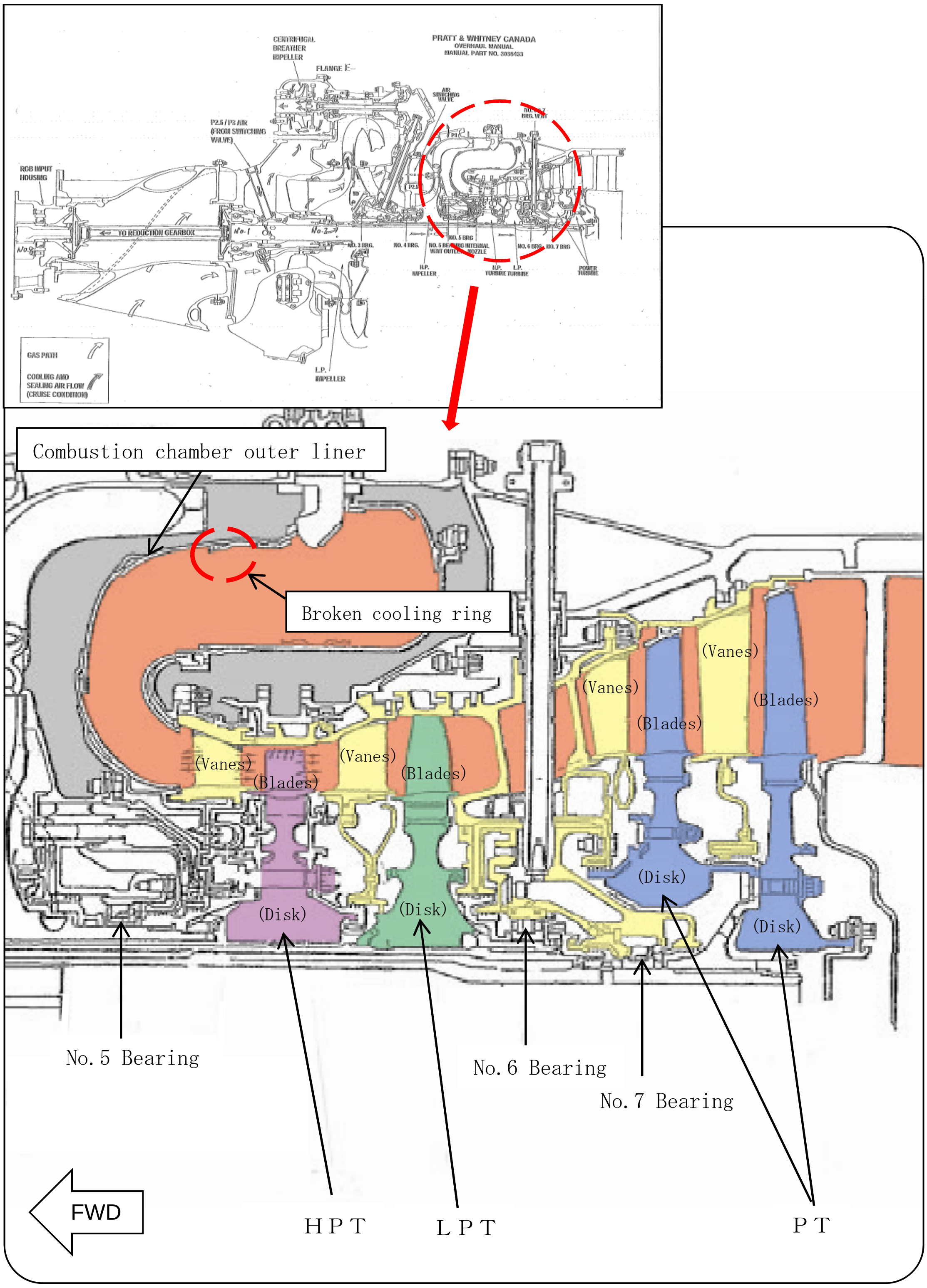


Figure 3　Engine Cross section




Quoted from Maintenance Manual

Photo 1 Serious Incident Aircraft


Photo 2 Around the Exhaust Duct of the Engine

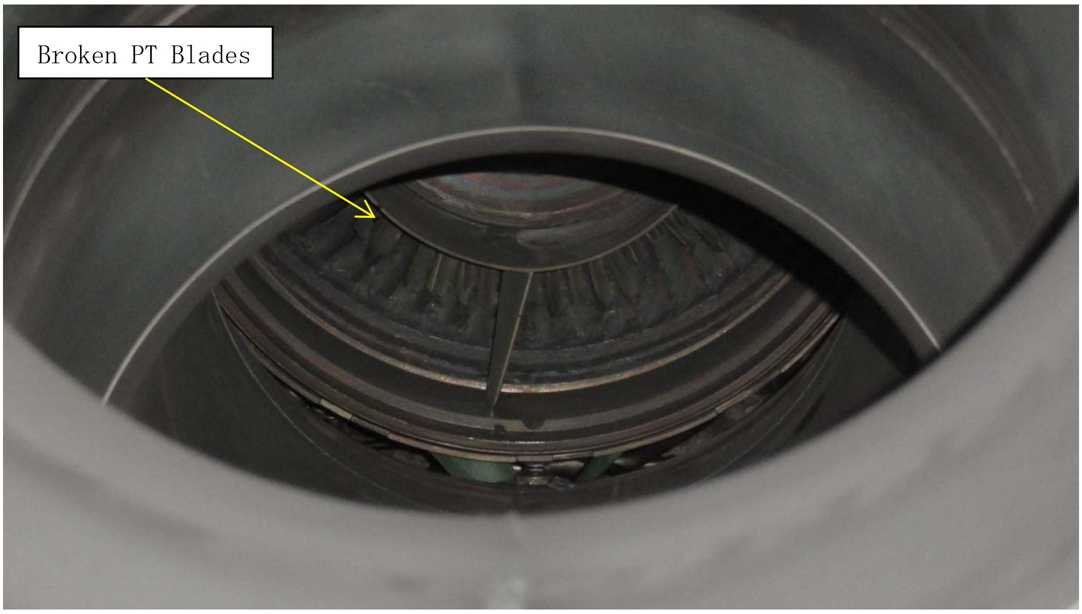


Photo 3　Combustion Chamber Outer Liner

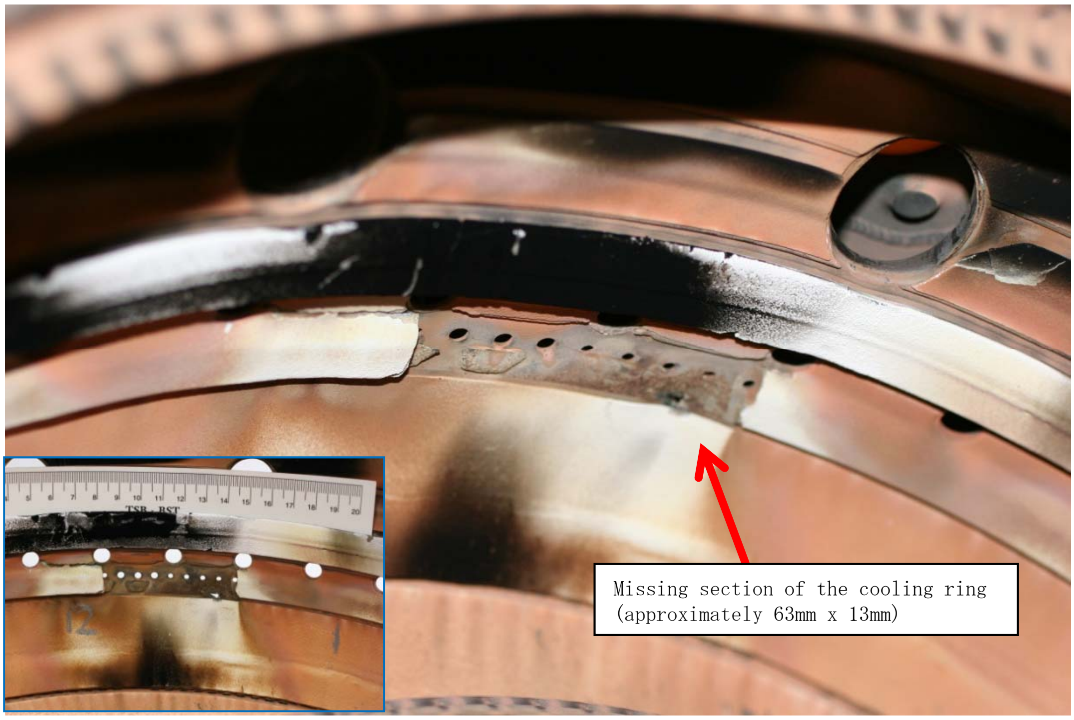



Photo 4　HPT Disk