KOMITE NASIONAL KESELAMATAN TRANSPORTASI
REPUBLIC OF INDONESIA

FINAL

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Aircraft Accident Investigation Report

PT. Wings Abadi Airline

ATR 72-212A (500 Version); PK-WFV

Sultan Hasanuddin International Airport, Makassar

Republic of Indonesia

18 September 2013

2023

This Final Report is published by the Komite Nasional Keselamatan Transportasi (KNKT), 3rd Floor Ministry of Transportation, Jalan Medan Merdeka Timur No. 5 Jakarta 10110, Indonesia.

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Jakarta, 21 November 2023

KOMITE NASIONAL
KESELAMATAN TRANSPORTASI
CHAIRMAN

SOERJANTO TJAHJONO

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ABBREVIATIONS AND DEFINITIONS

ACW	:	Alternating Current Wild
AFCS	:	Auto Flight Control System
AOM	:	Aircraft Operator Message
ATPL	:	Airline Transport Pilot License
ATS	:	Air Traffic Service
ATR	:	Avions De Transport Regional
BR	:	Blade Rotation
BEA	:	Bureau d'Enquêtes et d'Analyses (French investigation authority)
CL	:	Condition Lever
CLB	:	Climb
CPL	:	Commercial Pilot License
CRZ	:	Cruise
CVR	:	Cockpit Voice Recorder
daN	:	Deka Newton
DME	:	Distance Measurement Equipment
EEC	:	Engine Electronic Control
EGPWS	:	Enhance Ground Proximity Warning System
FCOM	:	Flight Crew Operating Manual
FDEP	:	Flight Data Entry Panel
FDR	:	Flight Data Recorder
FEM	:	Finite Element Method
FI	:	Flight Idle
FUEL SO	:	Fuel Shut Off
GEN	:	Generator (electrical)
GI	:	Ground Idle
ITB	:	Institut Teknologi Bandung (Bandung Institute of Technology)
ITT	:	Inter Turbine Temperature
KNKT	:	*Komite Nasional Keselamatan Transportasi* also known as National Transport Safety Committee, is the transportation safety investigation authority in Indonesia responsible to conduct aviation safety investigation accordance with the ICAO Annex 13.
lb	:	libra (ancient Roman unit) identical standards of mass to the pound. The lbf stand for pound of force

LT	:	Local Time
MAX PWR	:	Maximum Power
MCDU	:	Multifunction Control Display Unit
MCT	:	Maximum Continuous Thrust
NAC OVHT	:	Nacelle Overheat
Nm	:	Nautical Mile
OEB	:	Operation Engineering Bulletin
OIM	:	Operator Information Message
OVHT	:	Overheat
OVRD	:	Override
PEC	:	Propeller Electronic Control
PF	:	Pilot Flying
PL	:	Power Lever
PM	:	Pilot Monitoring
PVM	:	Propeller Valve Module
PW	:	Pratt and Withney
PWR MGT	:	Power Management
RPM	:	Rotation per Minute
SEM	:	Scanning Electron Microscope
SIC	:	Second in Command
SB	:	Service Bulletin
SHK	:	Statens Haverikommission (Swedish Accident Investigation Authority)
TO	:	Take Off
UTAS	:	United Technologies Corporation Aerospace System
UTC	:	Universal Time Coordinated
VMO	:	Maximum Operating Speed
VOR	:	Very High Frequency Omni Range
VS	:	Vertical Speed mode
VSS	:	Vibration Stress Survey

SYNOPSIS

On 18 September 2013 an ATR 72-500 aircraft registration PK-WFV was being operated on scheduled passenger flight by Wings Air with flight number IW 1333. The schedule flight route was the second flight of the day which was conducted from Haluoleo Airport, Kendari to Sultan Hasanuddin Airport, Makassar. On board of the flight were 2 pilots, 2 flight attendants and 70 passengers where the Second in Command acted as Pilot Flying (PF) and the Pilot in Command (PIC) acted as Pilot Monitoring (PM).

At 2339 UTC (0739 LT) the aircraft was airborne from Kendari. The departure of the flight until cruise was uneventful. At the time of the occurrence the weather at Makassar area was clear. Approximately 45 nautical miles from MKS VOR of Makassar, the pilot requested to descend. At the aircraft altitude approximately of 6,000 feet, the aircraft experienced heavy vibration but the engine instruments indicated normally. The Propeller Electronic Control (PEC) 2 fault, together with the Alternating Current Wild Generator (ACW GEN) 2 alerts was triggered. The PIC took over the control of the aircraft and instructed the SIC to call "mayday" to the Makassar Director controller informing that the aircraft experienced engine problem.

During aircraft descent the pilot noticed that the aircraft speed was between 230 and 240 knots. The PIC tried to evaluate the condition by moving both condition levers (CL) to 100%/OVRD, however the vibrations still existed and the pilot moved the CL back to AUTO notch.

At 0028 UTC (0828 LT) the aircraft landed safely on runway 31 with the use of reverse on both engines. The aircraft was on taxi to the apron when the NAC OVHT (Nacelle Overheat) warning of the right engine was activated and the pilot shut down the right engine. At the same time the vibration disappeared.

After the aircraft parked, the PIC inspected the right engine and found one propeller blade was in the feather position, one propeller blade was in the reverse position and the rest of the blades were in the un-feathered position. Afterward the engineer removed the propeller hub found a trunnion pin was broken and the forward yoke was deformed.

No one injured in this serious incident.

Based on the investigation, the contributing factor of this occurrence is as follow:

The trunnion pin of the propeller blade number 5 was broken during aircraft descend that led to the aircraft vibration. The fracture analysis showed that the failure of the trunnion pin of propeller blade number 5 was likely due to steady overload applied by the aft yoke plate during the changes of the propeller blade angle.

As result of the investigation the KNKT acknowledges the safety actions taken by PT Wing Abadi Airline, aircraft and propeller manufactures and considered that the safety actions were relevant to improve safety, therefore the KNKT did not issue safety recommendation

1 FACTUAL INFORMATION

1.1 History of the Flight

On 18 September 2013, an ATR 72-212A aircraft, registration PK-WFV was being operated on scheduled passenger flight by Wings Abadi Airlines (Wings Air) with flight number IW1333. The schedule flight route was from Haluoleo Airport, Kendari[1] to Sultan Hasanuddin Airport, Makassar[2]. The flight was the second of three schedule flights for the day on routes Makassar – Kendari – Makassar – Kendari and stop. The first flight from Makassar to Kendari was uneventful.

On board of the IW1333 flight was 2 pilots, 2 flight attendants and 70 passengers. In this flight the Second in Command (SIC) acted as Pilot Flying (PF) and the Pilot in Command (PIC) acted as Pilot Monitoring (PM).

At 2339 UTC[3] (0739 LT[4]) the aircraft departed from Kendari. The flight from departure until cruise was uneventful.

At distance approximately 90 Nm from MKS VOR (Very High Frequency Omni-range) of Makassar, while cruising at the altitude of 14,000 feet the pilot conducted the initial contact to Makassar Director controller and the pilot noticed that their flight would be in the sequence number 10 for landing in Makassar. About 10 minutes later, the controller instructed the pilot to fly direct to waypoint BADOK[5].

At the time of the occurrence the weather at Makassar and surrounding area was clear.

Approximately 45 Nm from MKS VOR, the pilot requested for descend clearance and was approved by Makassar Director controller to descend to an altitude of 9,000 feet. Thereafter, the Makassar Director controller instructed to continue the descent to altitude of 3,000 feet and was instructed to fly direct to MKS VOR.

The runway in use in Makassar was Runway 03. The pilot requested to land on Runway 31 which according to the pilot it was the closest flight path for approach and landing for a flight from Kendari. The request was not approved by the controller and instructed to fly direct to waypoint BADOK for preparing to land on Runway 03.

When the aircraft altitude approximately 6,000 feet, the pilots stated that the aircraft experienced heavy vibration but the engine instruments indicated normally. Propeller Electronic Control (PEC) fault on engine 2 (the right engine) and Alternating Current Wild (ACW) generator of the right engine were triggered during the event. The PIC took over the control of the aircraft and instructed the SIC to call "mayday" to the controller and to inform that the aircraft experienced engine problem. The SIC requested to the controller to use Runway 31 for landing and was not approved by the controller which then instructed the pilot to fly direct to the

1 Haluoleo Airport, Kendari of South East Sulawesi will be named as Kendari for the purpose of this report.

2 Sultan Hasanuddin Airport, Makassar of South Sulawesi will be named as Makassar for the purpose of this report.

3 The 24-hour clock used in this report to describe the time of day as specific events occurred is in Universal Coordinated Time (UTC).

4 Local time for Makassar is Central Indonesia Standard Time (*Waktu Indonesia Tengah* - WITA) or UTC + 8.

5 Waypoint BADOK located on radial 210° at 16 Nm from MKS VOR was the initial approach point for Instrument Landing System (ILS) approach Runway 03.

right downwind for preparation to land on Runway 03.

Considering the vibration on the aircraft, the SIC stated that the aircraft would not be able to land on Runway 03 and insisted to use Runway 31 for landing. The Makassar Director controller approved to land Runway 31.

The PIC moved left and right Condition Levers (CL) from AUTO to OVRD (override) one by one with intention to determine the source of vibration but the vibration remained and the source of vibration unable to be determined. The PIC placed the both CL to AUTO position.

During aircraft descent the pilot noticed that the aircraft speed was between 230 and 240 knots. The PIC moved the Power Lever (PL) to reduce the aircraft speed but the vibration became severe as speed decreasing, afterward the PIC returned the PL at previous position and maintained the aircraft speed at 210 – 220 Knots.

After Makassar Director controller transferred the flight to the Makassar Tower controller, the PIC conducted visual approach procedure to land on Runway 31.

At 0028 UTC (0828 LT) the aircraft landed safely on Runway 31 with the use of reverse on both engines.

During taxi to the apron the NAC OVHT[6] warning of the right engine active and the pilot shut down the right engine. After the right engine rotation decelerated, the aircraft vibration disappeared.

After the aircraft parked, the PIC inspected the right engine and found one of the propeller blades was in the feather position, one propeller blade was in the negative blade angle position and the rest of the blades were in the un-feathered position.

No one injured in this serious incident.

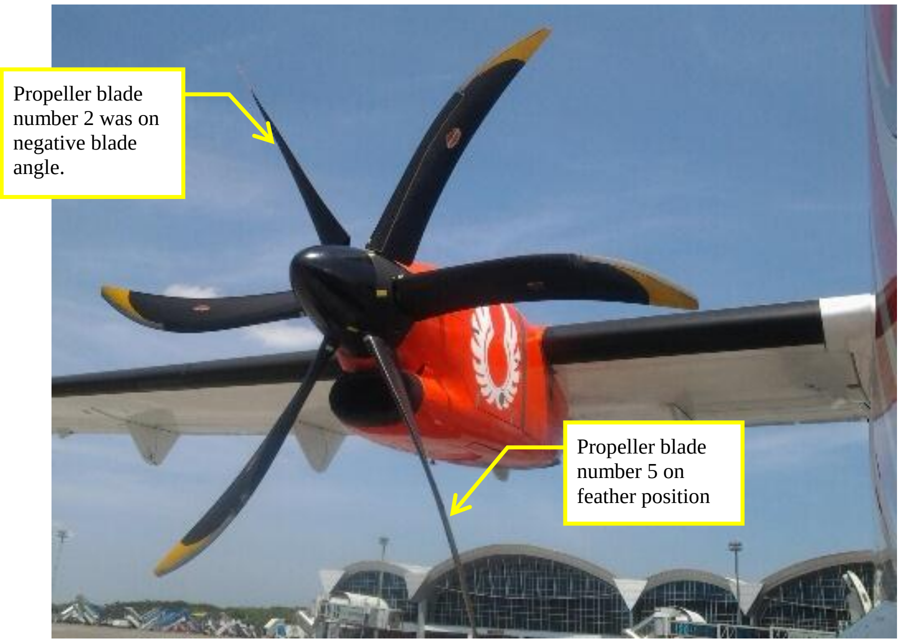

Figure 1: The right engine propellers condition after the aircraft parked

6 NAC OVHT (Nacelle Overheat) warning is activated if the temperature of the right engine nacelle exceeds 170°C when the aircraft is on ground. The NAC OVHT warning is available for the right engine only.

1.2 Damage to aircraft

The propeller system of the right engine and the rear right engine mounts (both) were damaged

The propeller spinner was opened and found that the counter weight of propeller blade number 2 in contact with counter weight of propeller blade number 3 as shown in the figure below.

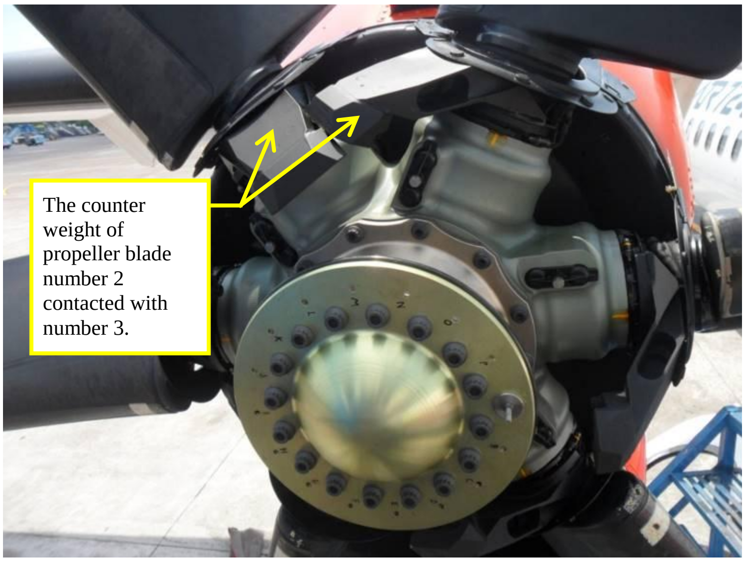

Figure 2: Propeller counter weight not in proper position

For further inspection, all propeller blades were dismantled from the propeller hub. It was found that on the propeller blade number 2, the bolt to secure the trunnion pin bearing with the trunnion support plate was broken.

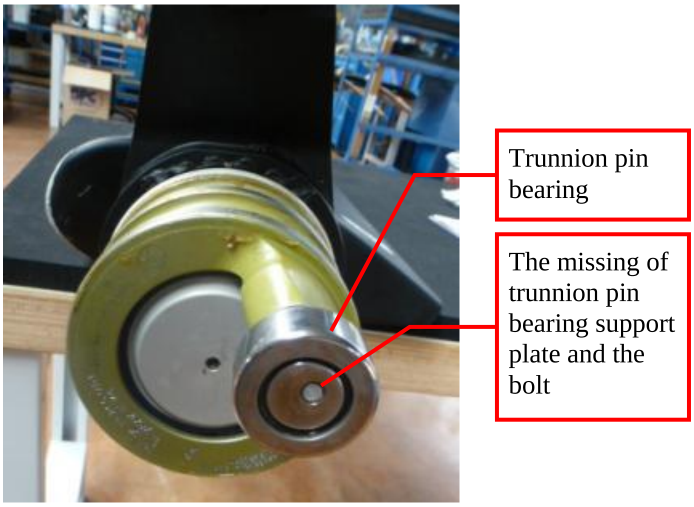

Figure 3: The trunnion pin of propeller blade number 2

The trunnion pin of propeller blade number 5 was broken as shown in the figure 4 below. The normal trunnion pin with the trunnion pin bearing is shown in the figure 5.

Figure 4: The broken trunnion pin of propeller blade number 5	Figure 5: Normal trunnion pin with the trunnion pin bearing

The ATR 72-212A, each engine mounts comprises 2 forward lateral shockmounts, 1 forward upper shockmount and 2 aft lateral shockmounts. The engineer examined the right engine mounts condition and found the both aft lateral shockmount structure were broken as shown in the figure below.

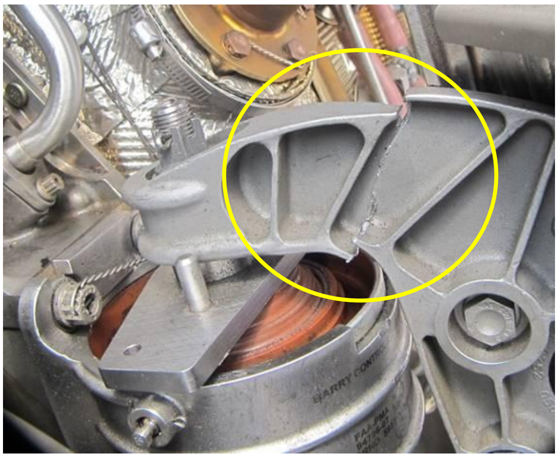

Figure 6: One of aft lateral engine mountings of right engine

The propeller assembly of right engine was removed and sent to the KNKT for further examination. The detail result of the examination is described in the chapter 1.7 Test and Research of this report.

1.3 Personnel Information

1.3.1 Pilot in Command

The PIC was 38 years old Indonesia pilot, joined the company since 11 October 2010. The PIC held Airline Transport Pilot License (ATPL) issued on 23 December 2011 with current rating of ATR 72 and first-class medical certificate which valid until 4 March 2014 without limitation. The PIC has conducted line check on 13 March 2013 and last simulator proficiency check was conducted on 13 June 2013.

The PIC Flying experience

Total hours	:	6,029 hours
Total on type	:	2,816 hours
Last 90 days	:	292 hours
Last 60 days	:	181 hours
Last 24 hours	:	5 hours 50 minutes
This flight	:	1 hours 10 minutes

1.3.2 Second in Command

The SIC was 30 years old Indonesia pilot who has joined the company since 1 June 2012. The SIC held Commercial Pilot License (CPL) with current rating of ATR 72 and first-class medical certificate which valid until 13 December 2013 with no limitation. The SIC has conducted line check on 29 October 2012 and last simulator proficiency check was conducted on 6 November 2012.

The SIC flying experience

Total hours	:	337 hours
Total on type	:	221 hours
Last 90 days	:	111 hours
Last 60 days	:	74 hours
Last 24 hours	:	5 hours 50 minutes
This flight	:	1 hours 10 minutes

1.4 Aircraft Information

1.4.1 General

This ATR 72-212A registered PK-WFV manufactured by Avions de Transport Regional (ATR) in 2011 with serial number 0985. The aircraft had valid Certificate of Airworthiness as transport category without limitation which was issued on 28 December 2012 and valid until 27 December 2013. The aircraft also had valid Certificate of Registration number 3014 which was issued on 28 December 2012 and was valid until 27 December 2013. On the day of the occurrence, the aircraft maintenance recorded that the aircraft had total cycle of 4,825 and total flight hours of 4,352 hours.

The remaining hours to the next major inspection for the aircraft was 6,148 while the last minor inspection (A8 Check) was conducted on 22 July 2013 when the aircraft had 3,976 flight hours.

1.4.2 Engine

Manufacturer	:	Pratt & Whitney, Canada
Type/Model	:	Turbo-propeller / PW 127M
Serial Number-1 engine	:	PCE-ED0453
▪ Time Since New	:	4,352 hours 08 minutes
▪ Cycles Since New	:	4,825 cycles
Serial Number-2 engine	:	PCE-ED0455
▪ Time Since New	:	4,352 hours 08 minutes
▪ Cycles Since New	:	4,825 cycles

1.4.3 Propeller

Manufacturer	:	Hamilton Sundstrand
Type/Model	:	Constant speed variable pitch (blade angle)/ 568F-1
Serial Number blade 1	:	FR 201005026RT
▪ Time Since New	:	4,713 hours
▪ Cycles Since New	:	5,079 cycles
Serial Number blade 2	:	FR201109065RT
▪ Time Since New	:	4,352 hours
▪ Cycles Since New	:	4,825 cycles
Serial Number blade 3	:	FR201109082RT
▪ Time Since New	:	4,352 hours
▪ Cycles Since New	:	4,825 cycles
Serial Number blade 4	:	FR201109086RT
▪ Time Since New	:	4,352 hours
▪ Cycles Since New	:	4,825 cycles
Serial Number blade 5	:	FR201109091RT
▪ Time Since New	:	4,352 hours
▪ Cycles Since New	:	4,825 cycles
Serial Number blade 6	:	FR201109093RT
▪ Time Since New	:	4,352 hours
▪ Cycles Since New	:	4,825 cycles

The propeller specification refers to the ATR Maintenance Manual is as follow:

Propeller diameter : 12.9 feet (3.93 meters)
Rotational orientation : clock wise (viewed forward from cockpit)
Rotational speed : 1,200 Rotation per Minute (RPM) corresponding to 100% NP indicator at take off
Pitch blade range (propeller blade angle range): -19° up to 78.5°
Feather angle : 78.5°
Reverse angle : -19° ± 0.5°

1.4.4 The Engine Power and Propeller Control

The engines power and propeller control are managed by mean of the positioning of the Power Lever (PL), the propeller Condition Lever (CL) and the Power Management (PWR MGT) selection.

The cockpit view of the PL, CL and PWR MGT are as follow.

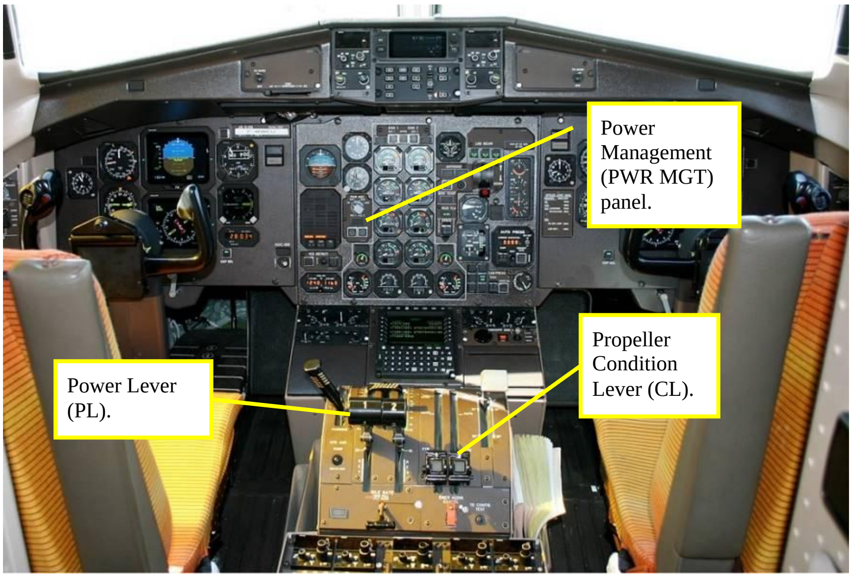

Figure 7: The Power Levers, Condition Levers, and Power Management panel

The PL controls the engine power. The PL can be adjusted between marked positions which are REV (reverse), GI (ground idle), FI (flight idle) and the NOTCH (detent) position and MAX PWR (maximum power). The position of the PL is shown in the figure below.

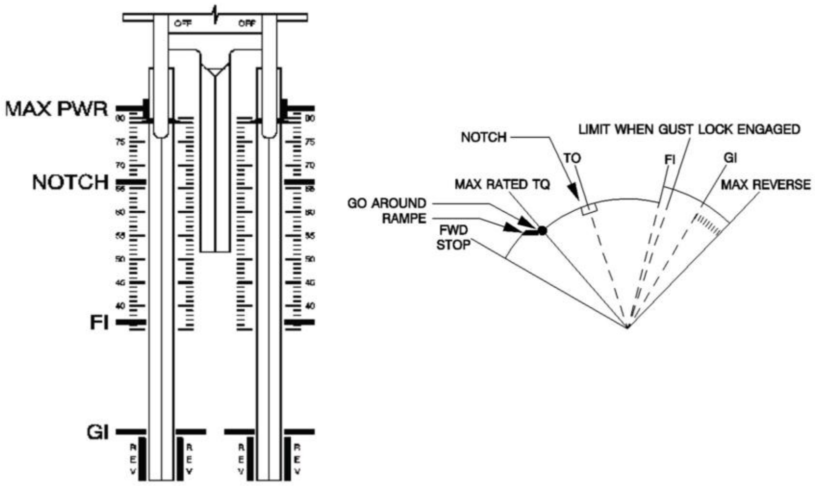

Figure 8: Illustrated Power Lever (PL) selection

The Condition Levers (CL) controls the propeller condition. Propeller speed control is managed by Propeller Electronic Control (PEC). The CL selection ranges are FUEL SO (fuel shut off), FTR (propeller feather), AUTO and 100 OVRD (override or set the propeller RPM to 100%). The engine shut down is conducted by selecting the CL on the FUEL SO position. The illustration of the CL is shown in the figure below.

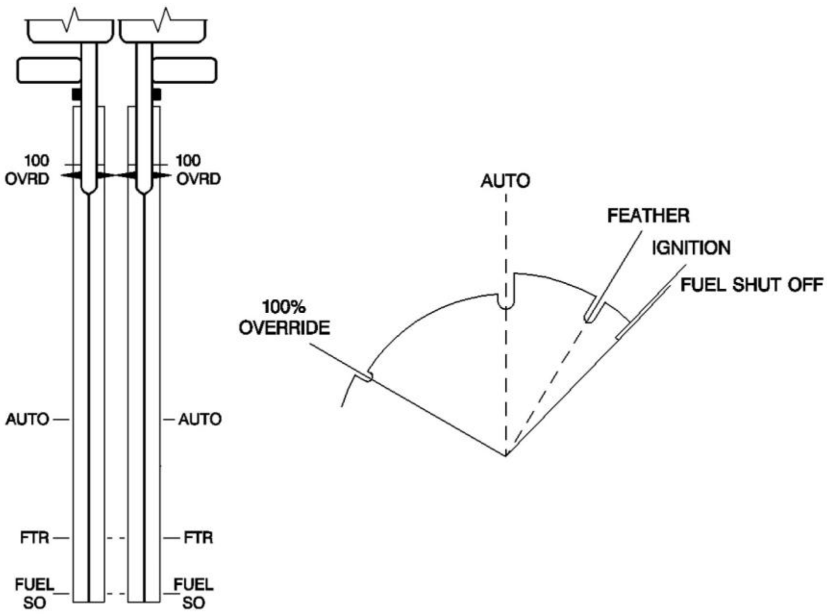

Figure 9: Illustrated Condition Lever (CL) selection

The PWR MGT (power management) panel provides the power selection for the specific flight phase condition. The selection of the flight phase can be managed by mean of rotary selector which has four selection positions consists of TO (take-off or go around), MCT (maximum continuous thrust selection during the single engine operation), CLB (climb) and CRZ (cruise). The illustrated of the PWR MGT panel is shown in the figure below.

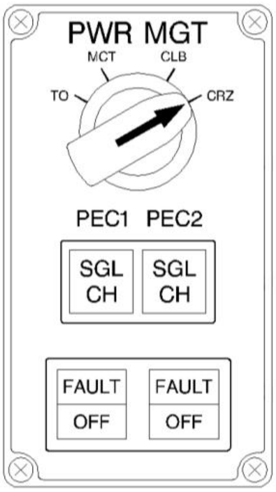

Figure 10: Power Management (PWR MGT) panel

The engine power setting in all flight phases are characterized by PL and CL positions combined with the PWR MGT panel selection (TO (takeoff), MCT (Maximum Continuous Thrust), CLB (Climb) and CRZ (Cruise)). The relationship of PL, CL and PWR MGT selection are as follow:

- In any position of the PL, CL, and any selection of the flight phase in the PWR MGT panel, the Engine Electronic Control (EEC) automatically controls the fuel supply to the engine.
- Positioning the PL in the NOTCH (detent), CL in the AUTO position and the selection of the PWR MGT panel will provide the following propeller RPM (NP) and torque (TQ) configuration:
    - Selection of TO in the PWR MGT panel will allow the NP to 100% with the TQ up to 90%.
    - Selection of MCT in the PWR MGT panel during the single engine operation will allow the NP to 100% with the TQ up to 90.9%.
    - Selection of CLB in the PWR MGT panel during climb flight phase will allow the NP to 82% with the TQ up to 97%.
    - Selection of CRZ in the PWR MGT panel during cruise flight phase will allow the NP to 82% with the TQ up to 94.5%.
- Positioning the CL in the 100 OVRD position will override the PWR MGT selection and allow the NP to 100%. The torque will be characterized by the PL movement.
- With the specific selection of the flight phase in the PWR MGT panel and the position of the CL, the Propeller Electronic Control (PEC) via Propeller Valve Module (PVM) maintains the propeller RPM (NP) by changing the blades angle.
- During the takeoff, the selection of the PWR MGT in TO (take-off) position, allows the NP to 100%. During climb (selection the PWR MGT to CLB) or cruise (selection the PWR MGT to CRZ), the NP is set at 82%. During descent until the aircraft landing, normally the PWR MGT is selected in TO position to allow the NP to 100% and to accommodate the go around if required.

During the flight, normally the CL is selected in the auto position. In auto position, the NP is controlled by the PEC via PVM in response to the PL movement and PWR MGT selection. Moving the CL to override (100% RPM) position, makes the propeller rotation set at 100% RPM and override the PWR MGT selection.

1.4.5 Propeller Blade Angle Management

The propeller system is variable pitch (blade angle) propeller which means the propeller blade angle is adjusted to optimum angle while maintaining the propeller RPM in various condition of flight such as takeoff, climb, cruise, and descend also to feather position. The propeller blade angle change mechanism is mounted in the propeller hub.

The propeller blade angle change mechanism system involving the PL, CL, PWR MGT, PEC, PVM, the actuator yoke and the propeller blade assembly.

The PEC is a dual channel electronic box that fitted on each engine. The four functions of the PEC are:

- Propeller Speed Governing
- Beta Scheduling[7]
- Synchrophasing
- Feathering and unfeathering

If one of the PEC channels is fail, the SGL CH light on the PWR MGT panel (see figure 10 of this report) will illuminate indicates that the PEC works on single channel. In the event of PEC single channel, control of propeller system will be automatically transferred to the backup channel if the fault was detected by the primary channel. During the PEC single channel, resetting of the PEC is not allows in flight and no pilot action required.

The PEC FAULT light illuminates on the PWR MGT panel (see figure 10 of this report) when the PEC loss both channels. Illumination of PEC FAULT light will trigger the master caution light to illuminate.

When the PEC senses the blade angle failure (loss of blade angle signal), PEC controls speed governing if PL above FI and fix pitch or full reverse below FI. In this case (the PEC loss of blade angle signal) the PEC internal memory will store the fault code of 67 or 68. The fault code 67 correlate with the "Sensed Blade Angle Fault" in the primary channel and fault code 68 correlate with the same fault in the back up channel of the PEC.PEC has the capability to detect failures and stored up to 8 faults in the PEC internal memory that can be accessed via Multifunction Control Display Unit (MCDU) by pressing the maintenance page selection.

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7 The beta angle for a specific operating condition is determined by the PEC from a map (or beta schedule) of the beta angle vs the power lever angle and airspeed.

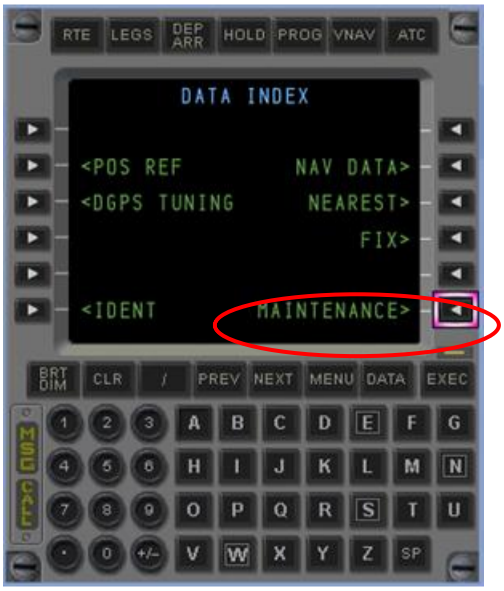


Figure 11: The maintenance page in MCDU

If the aircraft is equipped with the Flight Data Entry Panel (FDEP), the fault code associated with the failure that stored in the PEC internal memory can also be accessed via FDEP which mounted on the pedestal by selecting the toggle switch (ENG EEC/PEC SEL) on the right maintenance panel.

The illustration of FDEP is as follow.

Figure 12: The Flight Data Entry Panel

1.4.6 Propeller Blade Angle Mechanism

The simplified propeller blade angle mechanism consists of the PEC, PVM, and trunnion pin on each propeller blade root and actuator yoke plate.

The PEC command the PVM to move the actuator yoke plates by metering the oil pressure from the propeller gear box into the actuator dome via transfer tube assembly.

The illustration of the propeller blade angle mechanism is shown in the figure below.

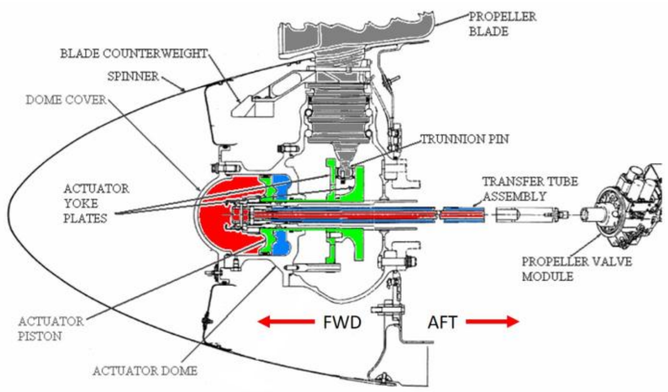


Figure 13: The schematic diagram of ATR Propeller Blade Angle Change Mechanism

The change of propeller blade angle initiates by the axial movement of the yoke plates. The axial movements of the yoke plates move the trunnion pin which transforms into a rotational movement of the blade along the center axis of the propeller blade.

To control propeller blade angle, the yoke plate uses metered pressure supplied by the propeller valve module through the transfer tube assembly. To increase the propeller blade angle, the yoke plate will move forward direction and to decrease the propeller blade angle the yoke plate will move to aft direction.

The illustration of the propeller blade angle change is shown in the figure below.

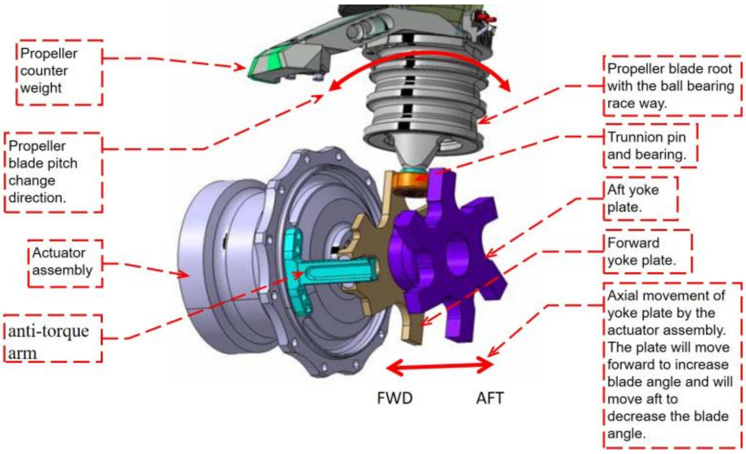


Figure 14: The illustration of propeller blade angle change mechanism

The yoke plate consists of forward yoke plate and aft yoke plate. The forward and aft yoke plates consisted of 6 arms to accommodate 6 propeller blades.

The end of the propeller blade (the propeller blade root) holds by the propeller hub and supported by two sets of balls bearing which enable the propeller blade to rotate along the center axis of the propeller blade during the propeller angle change.

The propeller blade root fitted with the trunnion pin supported by a trunnion pin bearing which is in contact with the surface of the yoke plate arms. The trunnion pin bearing is secured by the support plate and bolt. To make sure the blade trunnion bearings are not disengage from the yoke plates, the yoke plates is kept from turning through an anti-torque arm.

The illustration of the trunnion pin with the trunnion pin bearing is shown in the figure below.

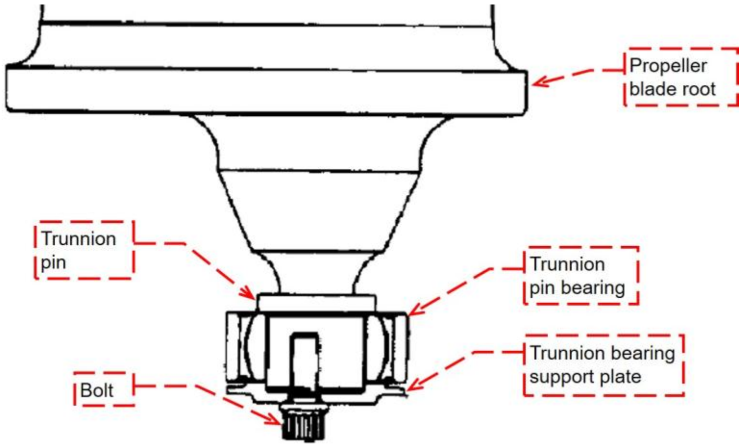


Figure 15: The illustration of the trunnion pin and bearing

1.4.7 Alternating Current Wild (AC Wild) System

The Alternating Current Wild (ACW) of the electrical system consists of two generators, one located on each engine and driven by the propeller reduction gearbox via a drive shaft. Each generator operates normally when the propeller RPM is greater than 66 % NP.

The ACW electrical power distribution utilizes three electric buses:

- Two main ACW 1 and 2 Buses;
- One ACW service bus.

The ACW 1 and 2 Bus normally powered by the left and right engine generator respectively. In the event of one generator failure, both buses will be energized by the remaining generator. If the ACW fault light illuminate, it means that the related generator was fail or the related propeller RPM is below 66% NP for 6 seconds or if NP drops below 52%.

The example of the ACW fault is shown in the figure below.

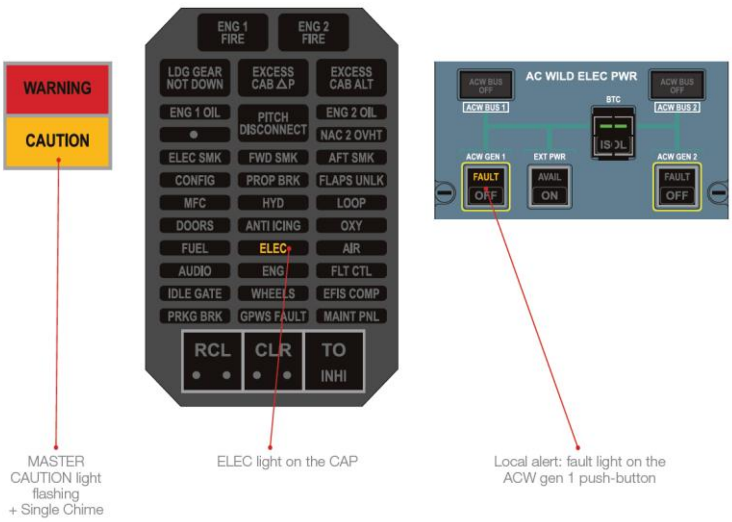


Figure 16: ACW fault light and relevant warning illumination

The investigation did not find any information regarding the condition of the right generator during the occurrence.

1.5 Flight Recorder

1.5.1 Flight Data Recorder (FDR)

The Flight Data Recorder (FDR) was removed from the aircraft and sent to the KNKT facility for data downloading process. The download process was successfully retrieved 25 hours of good quality data including the occurrence flight. The FDR information is as follow:

Manufacturer	: L3 Communication
Type/Model	: SSFDR / FA2100
Part Number	: 2100-4043-00
Serial Number	: 637111

The significant parameters recorded in the FDR are shown in the figure below.

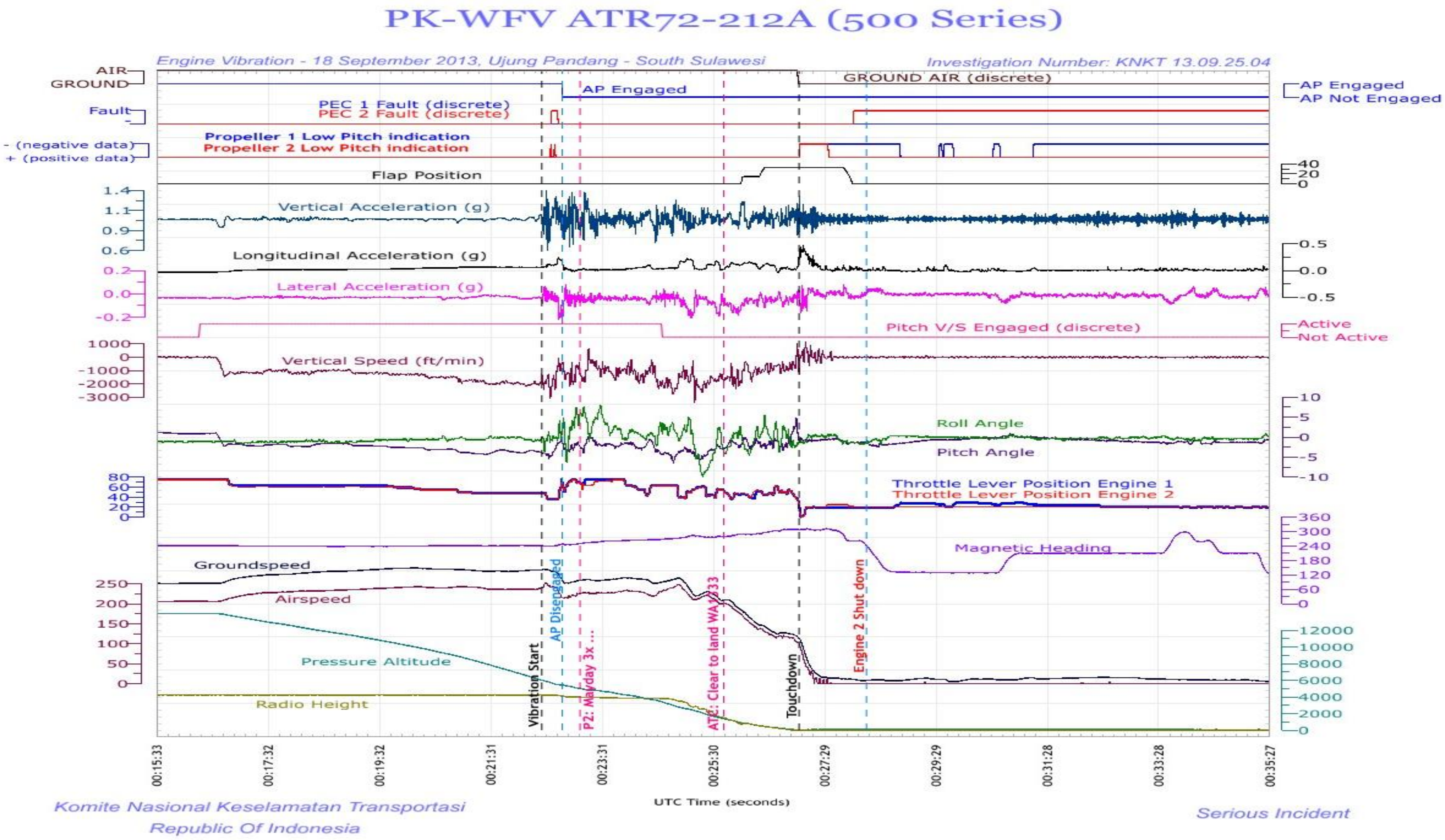


Figure 17: The FDR data started from the aircraft on descend from 12,000 feet until aircraft stop.

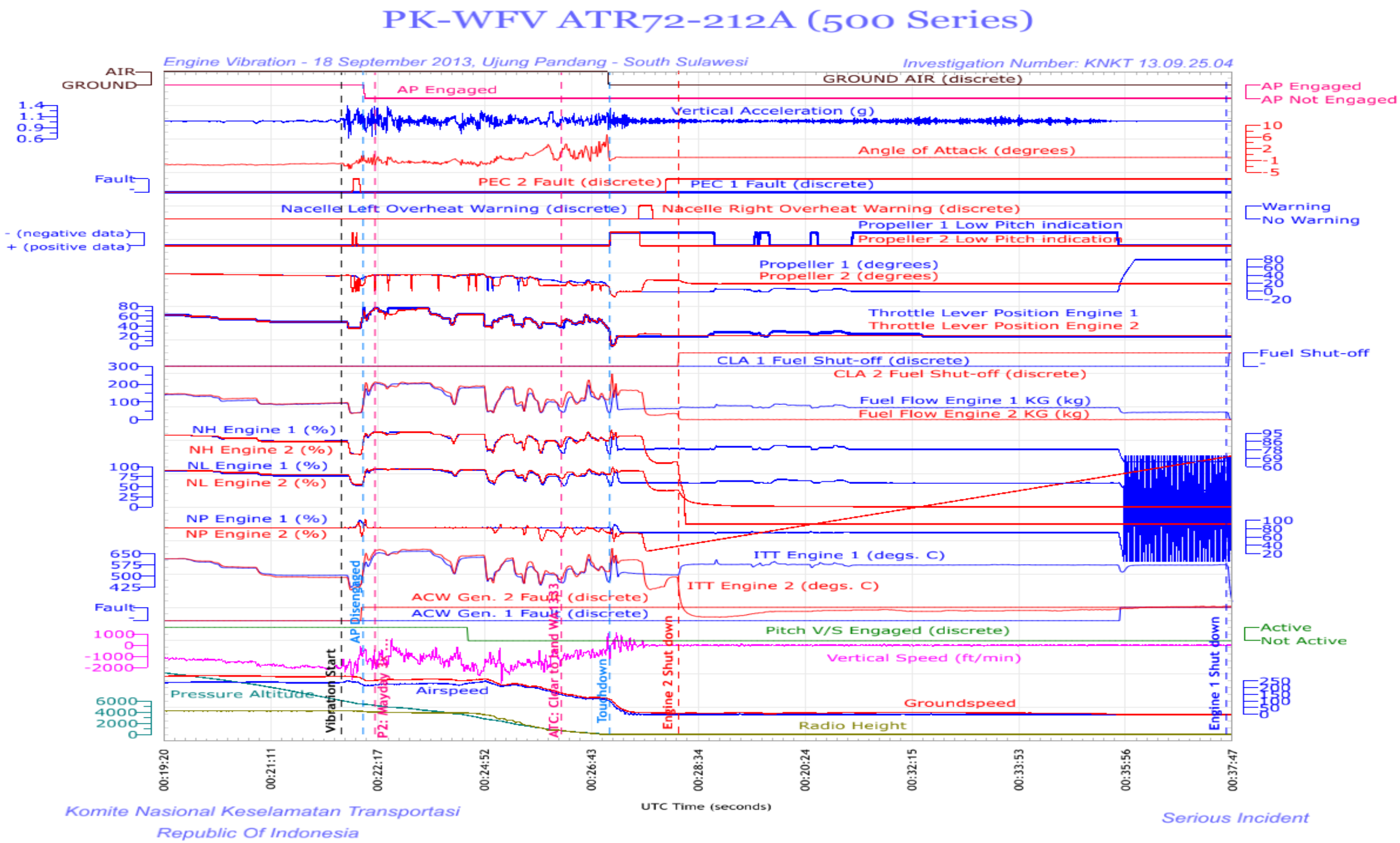


Figure 18: The FDR data during the event of the vibration

The FDR data showed significant events as follow:

1. At 00:16:21 UTC, the aircraft was cruising, the autopilot engaged and the vertical speed mode selected on VS mode.
2. At 00:16:41 UTC, the aircraft initiated the descent and the vertical speed selection on the AFCS was -1,500 feet/minute and the indicated aircraft speed was 206 knots.
3. At 00:22:25 UTC, the vibration started indicated by fluctuation of vertical acceleration and Angle of Attacks variation were recorded. The vertical speed selection on the AFCS was -2,000 feet/minute and the vertical speed recorded -2,130 feet/minute (aircraft on descend). The aircraft speed was 238 knots.

   Since the vibration started until the aircraft touched down, the propeller blade angle started to increase from 38° to 40°. The moving spike to zero of the right propeller blade angle is the expected response for a failure of the blade angle measurement system.
4. At 00:22:27 UTC, vertical acceleration started to vary. Propeller blade angle of both engines was 39° and increasing. The aircraft speed was 240 knots and increasing.
5. At 00:22:31 UTC, the aircraft speed reached 251 knots (more than 250 knots or VMO[8]) for 3 seconds, propeller blade angle reached 40.3° on both engines and started to decrease. The recorded vertical speed was -1,770 feet/minute.
6. At 00:22:33 UTC, the PL moved backward to FI position, torques, NL, NH decreased and both engines propeller blade angle decreased.
7. At 00:22:36 UTC, the NP indicated 82% (close to their target) the propeller blade angle of the right engine became invalid.
8. At 00:22:37 UTC, the recorded maximum vertical speed was -3,210 feet/minute (aircraft on descend), while the selected vertical speed on the AFCS was -700 feet/minute. At this time the aircraft speed was 242 knots.
9. At 00:22:38 UTC, the right Propeller Electronic Control (PEC) indicated fault for 7 seconds then back to normal. During the PEC fault, the right NP value was relatively lower than left engine while other parameters of both engines showed relatively at the same values.
10. At 00:22:47 UTC, right Alternating Current Wild (ACW) generator number 2 (right engine) indicated fault and the right NP indicated 62%. The right ACW remained fault until the end of recording. The right NP varied above 66%.
11. At 00:22:50 UTC, the autopilot disengaged.
12. At 00:23:14 UTC to 00:23:56 UTC the left Power Lever (PL) was higher than right PL for 43 seconds. At this time the aircraft altitude was about 4,000 feet, the aircraft speed was 233 knots and the aircraft heading was 262°.
13. At 00.24.49 UTC, the aircraft altitude was about 3,000 feet, the aircraft speed was 240 knots and the heading was 271°.

---

8 The VMO is maximum operating speed

14. At 00:26:09 UTC, the aircraft altitude was about 800 feet, the aircraft speed was 157 knots, the aircraft heading was 289, the flap position was 15 and the landing gear had been selected to down position.
15. At 00:26:27 UTC, the aircraft altitude was 468 feet, the aircraft speed was 131 knots, the aircraft heading was 297, the flap position was 33 and the landing gear had been selected to down position.
16. At 00:27:03 UTC the aircraft touch down. One second later, the PL angle moved backward for 6 seconds indicated the selection of propeller angle to reverse. A second later, both propeller blade angle showed negative value up to -14° (expected the maximum propeller blade reverse angle). The FDR recorded that after the application of reverse, while the PL of both engines at the same position, the NL (the engine low pressure compressor), NH (the engine high pressure compressor) and Inter Turbine Temperature (ITT) of the right engine were significantly higher than the left engine.

    After the reverse power applied and PL was moved to the idle position, all right engine parameters stayed at high value except the NP.

    Note:

    The parameter of CL angle was not recorded by the FDR. The CL parameter available in the FDR is the position of shut off and open therefore the change of CL angle was undetermined.
17. At 00:27:34 UTC, the right engine NAC Overheat warning active. Afterward, after the left PL indicated 20° and the right PL indicated 25°, the left propeller blade angle value about 0° while the right propeller blade angle start increasing from 0° up to 28°.
18. From 00:27:43 UTC until the end of the recording, the right engine NP value was not recorded on the FDR while the other parameters were recorded normally.
19. At 00:28:02 UTC until the end of recording, the right PEC was indicated fault.
20. At 00:28:15 UTC, the Condition Lever Angle (CLA) 2 moved to shut off followed by decelerating of all right engine parameters, indicated that the right engine was shut down.
21. At 00:35:53 UTC, the ACW 1 fault.
22. At 00:37:45 UTC, the left engine shut down indicated by the movement of the left CLA 1 to shut off.
23. At 00:42:08 UTC, the end of recording.

1.5.2 Cockpit Voice Recorder

Manufacturer : L3 Communication

Type/Model : SSCVR/ FA2100

Part Number : 2100-1020-02

Serial Number : 617459

The CVR was removed from the aircraft and sent to KNKT facility for data downloading process. The recorder contained 4 channels in two hours with good quality data including the occurrence flight.

The excerpt of the CVR information was described below.

Note:

- Time is UTC time synchronized with the FDR.
- P1 = PIC
- P2 = SIC
- Kendari tower = Kendari Tower controller
- Cabin = Flight Attendant
- EGPWS = Enhanced Ground Proximity Warning System

Time (UTC)	Event
23:39:21	The Kendari Tower controller issued take off clearance bound to Makassar via airway W41.
23:58:42	The P1 reported to Kendari Approach controller that the aircraft was reached flight level 140 and the position was 89 DME from Makassar. The Kendari Approach controller acknowledged the message and instructed the pilot to contact Makassar radar controller
00:01:18	The Makassar Radar controller acknowledge the contact and instructed the pilot to maintain flight level 140 heading to MKS VOR for vectoring to ILS runway 03.
00:11:12	The Makassar Radar instructed the pilot to direct to waypoint BADOK and acknowledged by the pilot.
00:16:19	The P1 requested to the Makassar Radar controller for descend visual and approved by Makassar Radar controller. The Makassar Radar controller instructed the pilot to descend to altitude 9,000 feet.
00:18:59	The Makassar Director controller instructed the pilot to continue descend and to fly direct to waypoint BADOK.
00:19:39	The P1 communicated with another pilot discussed the traffic congestion. The aircraft was on sequence number 10. This discussion took about 1 minute.
00:20:29	The Makassar Director controller instructed the pilot to continue descends to altitude 3,000 feet.
00:22:23	While on descends, the P1 requested to the Makassar Director controller to land on runway 31. The Makassar Director controller did not approve the P1 request and instructed to continue descends to 3,000 feet.
00:22:24	The CVR recorded a change in engine sound and followed by sound of warning chime. The P1 took the aircraft control from P2.

Time (UTC)	Event
00:22:31	Sound like overspeed aural warning (clacker charge).
00:22:50	Sounds like auto pilot disengage warning twice.
00:22:55	The Makassar Director controller instructed to the P1 for preparing landing to Runway 03.
00:22:57	Sound like a warning chime.
00:23:01	The P2 broadcasted distress message (Mayday) and reported that they experienced engine problem and requested to land on Runway 31.
00:23:09	The Makassar Director controller reconfirmed whether the aircraft had problem and replied by the P2 that the aircraft had engine problem. Subsequently the Makassar Director controller asked whether the flight able to join right base Runway 03 and responded negative by the P2. The Makassar Director controller granted the request to land the Runway 31.
00:23:27	Both pilots discussed the aircraft problem and P1 commanded the P2 to check the engine parameter. The P2 responded that all engine parameters were normal.
00:23:54	The Makassar Director controller instructed the P2 to join final Runway 31 and instructed to contact Makassar Tower controller.
00:24:05	The P2 contacted Makassar Tower controller and repeating the distress message with addition that the aircraft was experiencing engine problem. The Makassar Tower controller acknowledged then instructed the P2 to continue approach and report when runway in sight.
00:24:20	Sound like a warning chime.
00:24:39	The pilots discussed about the severe vibration while all engine parameters were indicated normal.
00:24:49	The P2 advised the cabin crew for landing.
00:25:15	The P2 reported to the Makassar Tower controller that the runway had been in sight. The Makassar Tower controller acknowledged and instructed the P2 to report on final.
00:25:23	The P2 reported that the aircraft was on final Runway 31. The Makassar Tower controller issued landing clearance.
00:26:17	Sound like a warning chime twice.
00:26:25	EGPWS “Five hundred” aural message.
00:26:28	Sound like a warning chime.
00:27:03	Sound of aircraft touchdown.
00:27:10	The P2 reported to the Makassar Tower controller that the aircraft was touch down. The Makassar Tower controller asking whether the pilots

Time (UTC)	Event
	required assistance. The P2 responded that they did not require any assistance.
00:27:34	Sound of engine fire warning.
00:27:37	The Makassar Tower controller reconfirmed whether the aircraft required assistance or ground equipment and responded by the P2 that the aircraft able to taxi normally.
00:28:17	The pilots discussed to shut down the right engine.
00:28:24 until 00:29:21	The P1 discussed with another pilot via radio about the severe vibration and they unable to identify the cause of the vibration.
00:29:42	The Makassar Tower controller advised the P1 that during taxi, the aircraft would be followed by the airport fire fighting vehicle. The P1 acknowledged and asked the Makassar Tower controller whether any sign of fire or smoke from the right engine. The Makassar Tower controller responded that there was no sign of fire or smoke on the right engine.
00:32:33	The P1 discussing with the cabin about the aircraft situation and the cabin reported that during the aircraft vibration, smoke and unusual smell appeared in the cabin but there was no sign of fire.
00:35:48	The pilot conducting the checklist for shut down left engine.
00:37:45	Sound like engine decelerating.
00:42:08	End of recording.

1.6 Organizational and Management Information

1.6.1 General

Aircraft Operator : PT. Wings Abadi Airlines

Address : Jl. Gajah Mada Number 7, Jakarta 10130

AOC Number : AOC 121/002

The Wings Air authorized to conduct scheduled and unscheduled operations to carry passenger and cargo in domestic route within Indonesia and international route with no geographic restrictions. On the day of the occurrence, Wings Air operated 57 ATR aircraft.

1.6.2 Flight Crew Operating Manual (FCOM)

The FCOM ATR 72 described the descend charts are established with 3 speed laws of 200, 220 and 240 knots in the two kinds of descend specified as given rate and given gradient.

ATR 72 F.C.O.M.	DESCENT	3.07.01		
		P 1	500	
	INTRODUCTION			APR 11

AA

Descent charts are established in clean configuration for one reference weight (15000 kg = 33000 lb) and 3 speed laws :
- 200 kt
- 220 kt
- 240 kt

Two kinds of descent are proposed :

- at given rate
  from cruise altitude, descent at 1500 ft/mn (or 2000 ft/mn with pressurization in FAST mode)
  1) set cruise PLA up to the desired descent speed
  2) maintain descent speed and rate of descent

- at given gradient
  from cruise altitude, descent at chosen gradient (3° with pressurization in NORMAL mode, 4° or 5° with pressurization in FAST mode)
  1) set cruise PLA up to the desired descent speed
  2) maintain descent speed and gradient of descent

From 1500 ft to final landing, the tables are calculated with time and fuel allowances of :
- 3 mn for the time
- 30 kg (66 lb) for the consumption

WEIGHT CORRECTION

- on fuel consumption

  Increase the fuel consumption by :
  + 4 % at 1500 ft/mn of rate of descent
  + 5 % at 2000 ft/mn of rate of descent
  + 2 % at 3° descent gradient
  + 3 % at 4° descent gradient
  + 4 % at 5° descent gradient
  for a 1000 kg (2200 lb) weight decrease.

- No correction for weight increase.

- No influence on time and distance.

Mod : 5948 Eng. : PW127F / PW127M

Figure 19: Descent performance described in the FCOM

The descend procedure stated in the FCOM ATR 72 described the normal descend guidance with the given rates, speeds and the reference of average fuel, time and distance required.

1.7 Test and Research

1.7.1 Examination of the Propeller

On 2 and 3 October 2013, the metallurgic inspection by mean of stereo microscope inspection to the broken part of the trunnion pin conducted in Bandung Institute of Technology (*Institut Teknologi Bandung* – ITB) metallurgy facility.

The stereo microscope visual inspection found indication of beach marks on the broken trunnion pin of the propeller blade number 5. The inspection by Scanning Electron Microscope (SEM) showed a dimpled rupture[9] fracture as an indication of an overload (see chapter 1.7.2 point 5).

Figure 20: Crack initiation found on the trunnion pin of blade number 5

The visual inspection of the propeller blade number 2 found crack on the trunnion pin and broken on the roller bearing bolt.

Figure 21: Crack indication on the trunnion pin of propeller blade number 2

9 A dimple rupture refers to a type of material failure on a metal's surface that is characterized by the formation and collection of microvoids (a microscopic void (tiny hole) in the crystal structure of a metal) or microvoids coalescent along the granular boundary of the metal. The dimple rupture is an indication of an overload (Metallurgy of Failure Analysis, McGraw Hill).

The inspection of the actuator yoke found that all the forward yoke plate arms were deformed with estimated displacement of the yoke plate arms are between 4 and 15 millimeters from the original condition.

The forward and aft yoke plate exhibited functioning marks (worn marks) in all 6 yoke plate arms.

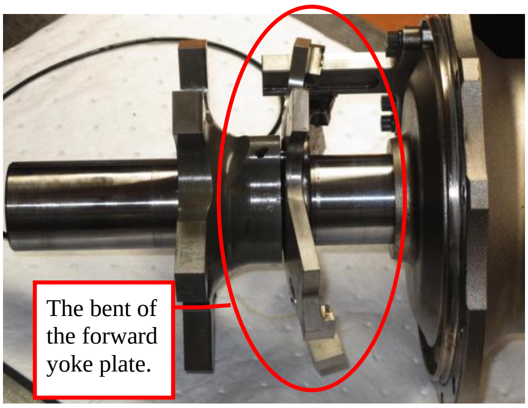


Figure 22: The bend of the forward yoke plate

Figure 23: The worn mark on the one of the aft yoke plates

1.7.2 The Aircraft and Propeller Manufacturer Test and Research

The ATR (Aircraft Manufacturer) and United Technologies Corporation Aerospace System (UTAS) which latterly became Collins Aerospace (Propeller Manufacturer) conducted several tests and researches regarding the occurrence of broken blade trunnion pins.

1. In 15 October 2013, the Aircraft and Propeller Manufacturer issued the examination report regarding the visual inspection of the propeller which was conducted by KNKT, ATR and Propeller Manufacturer in ITB metallurgy facility. The report described the visual inspection result of the right engine propellers. The report also recommended conducting detail inspection in the propeller manufacturer facility.

2. In February 2014, the Aircraft and Propeller Manufacturer utilized the ATR Vibration Stress Survey (VSS). The test flight was conducted in 2 sorties. The VSS was conducted as result of the flight test for observing the vibration in flight. For the observing purposes, the ATR set up a dedicated aircraft equipped with instrumentation on both propellers. The result is as follows:

   A. Aircraft Set Up for the Vibration Stress Survey (VSS)

      The VSS was carried out with the objective as follows:

      a. Determine if there are trunnion pin load differences between right and left side propellers.

      b. Determine if there are trunnion pin load differences between the test on 1994 VSS results (during the certification) and the test on 2014 Trunnion survey results

      c. Determine whether the test on 2014 trunnion pin and actuator VSS load data show friction is present to support that build-up of blade retention friction occurs on the ATR72/568F installation. The intention of the test on 2014 survey was to verify friction is present on this installation. It was not expected that the test on 2014 survey would produce propeller loads that would be high enough to cause a failure of the blade trunnion pins.

B. The Vibration Stress Survey (VSS) Test Set up

a. The propellers of both engines were set up with strain gauge instrumentation and individual telemetry hardware mounted on each propeller. The strain gauges (calibrated to a known moment load) were installed to the blades number 2, 5 and 6 on each propeller.

b. Each blade has a radial and tangential trunnion gauge calibrated to output pin forces.

c. Pressure transducers on the Propeller Valve Module (PVM) were used to record actuator course and fine pressure during the entire stress survey.

C. The Vibration Stress Survey (VSS) result

a. In determining the blade trunnion pin load differences between right and left side propellers, the result summary is as follow:

i. During flight with wings level the left side blade trunnion pin loads are about 6% higher than right side.

ii. Operating during high bank angle turns showed that the right side blade trunnion pin loads can be higher than the left side. Bank turns performed during the 2014 VSS are inside the flight envelope of the ATR72 aircraft but more extreme than anything seen in FDR recordings provided to Propeller Manufacturer for review.

b. The magnitude of the blade cyclic loads during the descent maneuvers is lower than all other phases of flight except during cruise. Right propeller cyclic blade loads during transition to high aircraft descend speed were 1.3 to 2 times greater than the left propeller loads which is far below the level that would cause damage.

i. Trunnion VSS blade cyclic loads show good correlation to blade loads recorded during the ATR72/568F VSS certification testing. From these results it can be concluded that the test conducted in 2014 showed that the blade moments and trunnion cyclic loads are similar to what was observed on the test conducted in 1994 (during the certification).

ii. Reverse and feather operations were the operating condition where test data confirmed the front actuator plate was loaded. All other conditions showed that the aft plate is loaded.

c. In determining whether the test conducted in 2014 trunnion pin and actuator VSS load data show friction is present to support that build-up of blade retention friction occurs on the ATR72/568F installation, the results are as follow:

i. Hysteresis loops performed before and after VSS first and second flight test show that a measurable friction increase is built up during both flights.

ii. The maximum total actuator friction observed from the hysteresis loops was 4,000 lbf (trunnion load 4000/6 = 670 lbf). Load required to fracture trunnion pin is approximately 14,000 lbf (6,227.5 daN).

iii. Loops show that friction is released after the engines are shut down and propellers stop rotating.

iv. Friction built up during loops on a percentage basis is similar to another Propeller Manufacturer installation that exhibited high blade retention friction

v. Trunnion VSS loads show higher than expected fluctuation of trunnion loads during approach at low power. This is viewed by Propeller Manufacturer as another example of increased friction in the propeller blade retention system.

d. Summary of Hysteresis Loops

i. Friction accumulated during flight operation can be as much as 8 times the values that were measured pre-flight or post engine shut down

ii. First flight test results gave a trend that the right engine propeller had higher blade retention friction compared to the left side propeller. The second flight test data did not show any consistent trend. Because of the scatter observed for both flights it is difficult to make a conclusion on left compare to the right behavior without additional flight test data.

D. Trunnion VSS Main Conclusions

a. Blade Cyclic Loads were found to be higher on the right propeller during high aircraft descends speed. All other operating conditions gave expected left and right results

b. Comparison of propeller load differences between the results of the VSS test conducted in 1994 (during the certification) and the test conducted in 2014 data showed no significant differences between the two tests.

c. Plots of ground hysteresis loops provided evidence that there was friction build up during first and second flights tests. The actuator load increase is verified by both the actuator pressure and trunnion load test data.

3. Propeller Actuator Yoke and Roller Bearing (Trunnion Pin Bearing) Analysis

On 20 December 2013, Propeller Manufacturer performed the material test to the propeller actuator yoke, trunnion pin and roller bearing (trunnion pin bearing). The report included the research conducted to the trunnion pin and the actuator yoke.

The material test to the actuator yoke, trunnion pin and bearing showed that all material were within the manufacture specification.

The examination on the yoke plates found that, the forward and aft yoke plates exhibited worn marks. In the normal operation, worn marks are considered normal as the bearing of the trunnion pin was in contact with the yoke plate arms.

The only time the trunnion pin bearing in permanent contact with forward yoke plate in normal operation is when the propeller selects to reverse and feather.

The worn mark on all aft yoke plate arms illustrated in the figure below.

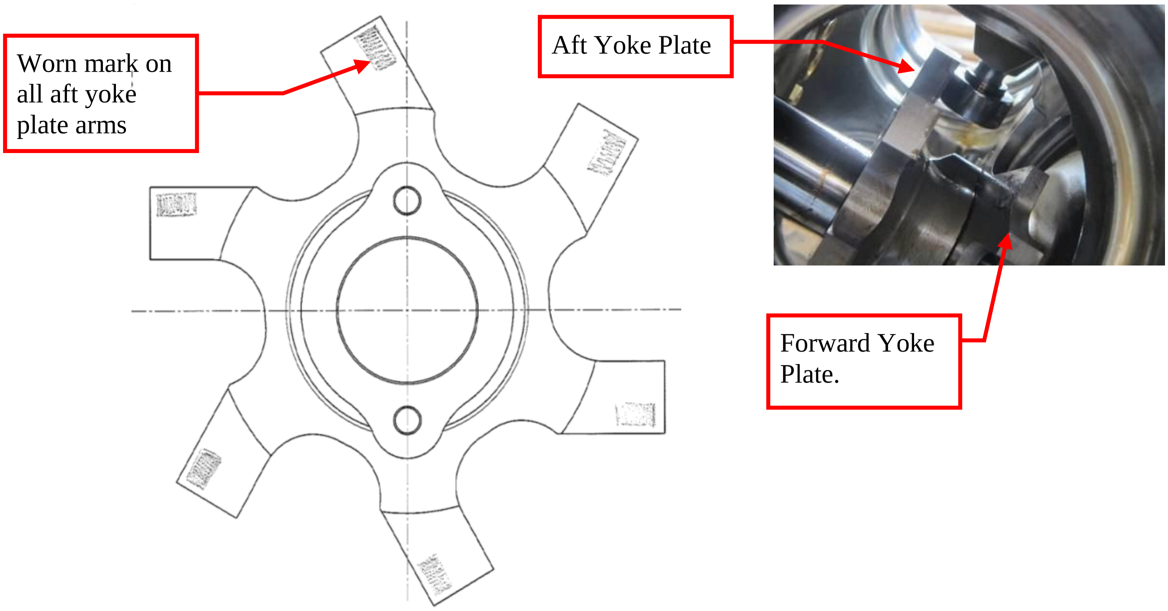


Figure 24: The worn marks on the surface of aft yoke plate

The Finite Element Method (FEM[10]) was conducted to determine the mode of plastic deformation of the yoke. The force required to cause plastic deformation of the forward yoke plate depends of the load application point. Base on the FEM, it was shown that the load required to plastic deformation of the forward yoke plate was about 3,000 daN (6,750 lbf).

4. In 6 March 2014 and 22 May 2014, the Propeller Manufacturer provided to the investigation the result of non-linear load analysis utilizing FEM. The FEM showed the forward yoke plate was displaced (bent) about 7 – 20 millimeters from the original position when the trunnion pin provides the load of 4,700 daN. At the load 4,700 daN the trunnion pin also bent about 2 – 2.4 millimeters. The aft yoke plate design was thicker than the forward yoke plate therefore it will require higher load to bend.

5. In 23 October 2014, the Propeller Manufacturer completed the detail examination to the right propeller and provided the examination result to the KNKT. The summary of the examination is as follow:

    a. There was no evidence of corrosion to the subject material. The material characteristics and hardware geometry (except for damaged parts) were compliant with the requirements.

    b. The examination of the forward yoke plate arm number 2, found residual bending of 14.4 mm (0.567 in). With this amount of bending, the trunnion bearing support plate would have been in contact with the forward yoke plate when reverse power was commanded.

10 The finite element method (FEM) is a numerical technique used to perform finite element analysis (FEA) of any given physical phenomenon.

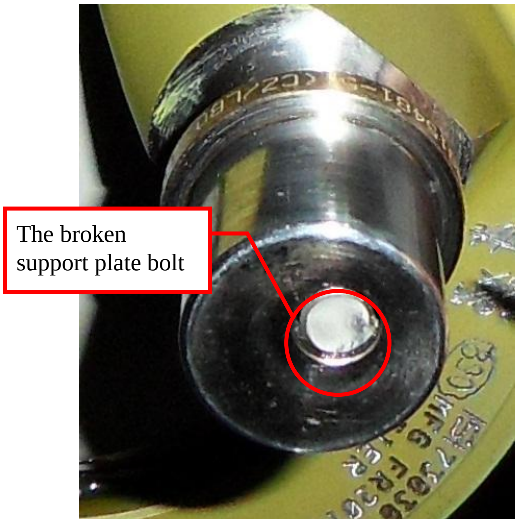


Figure 25: The broken bolt on the trunnion pin of propeller blade number 2

The estimated resultant of the trunnion bearing support plate which in contact with the forward yoke plate is shown with the blue arrow in the figure 26 below. The contact of the trunnion bearing support plate with the forward yoke plate created a shear load to the bolt which resulted in the broken of the support plate bolt.

The illustration of the failure of trunnion pin of propeller blade number 2 is shown below.

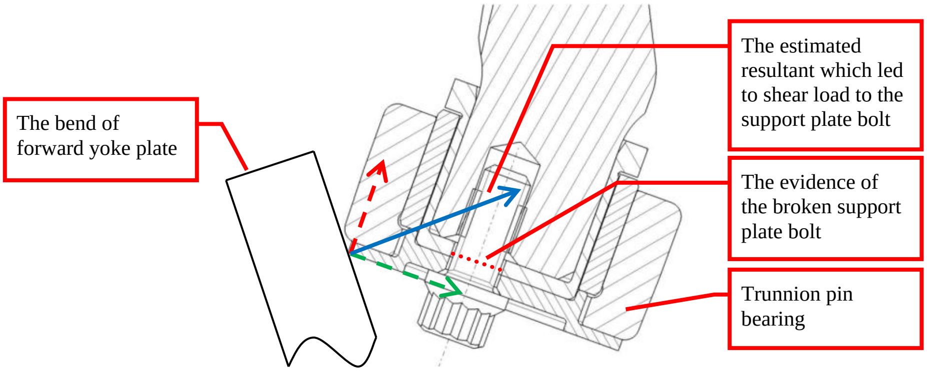


Figure 26: The illustration of the failure of support plate bolt of trunnion pin number 2

c. The trunnion pin of propeller blade number 5 was found broken. The fracture analysis showed that the fracture was likely due to steady overload applied by the aft yoke plate.

The detail examination of the fracture showed that the origin or the fracture was corresponding with the angle approximately of 13° relative to the red dashed line corresponding to a ¾ radius propeller blade angle of approximately 39° (minimum in-flight blade angle). The illustration of the fracture origin is shown in the figure below.

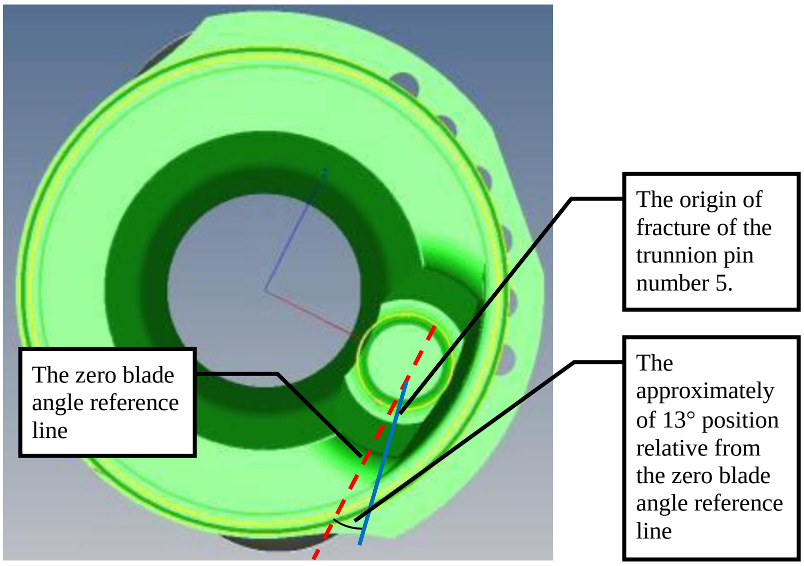
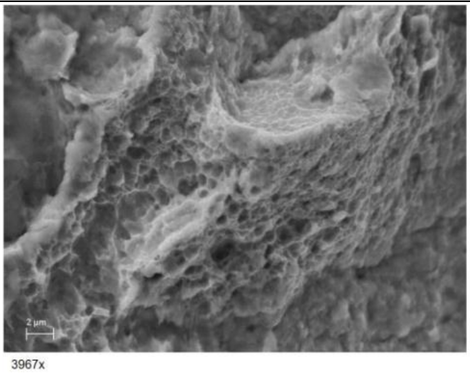


Figure 27: The estimated propeller blade angle corresponds to the origin of fracture trunnion pin

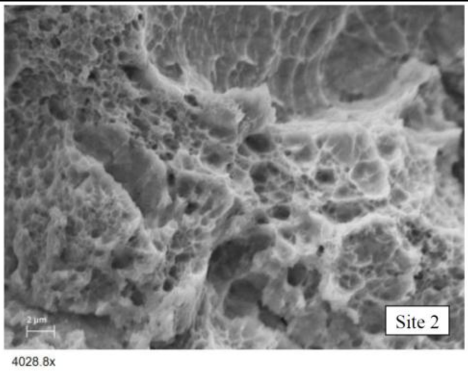
The fracture analysis was consistent with the SEM examination result which showed the dimple rupture (overload) fracture to the trunnion pin. The dimple rupture characterized with the appearance of microvoids. The SEM result is as follow:

Figure 28: The SEM examination areas of 1 to 7

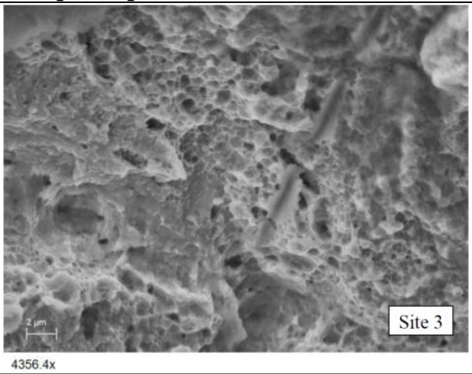
The detail SEM image of area 1 to 7 is shown in the figures below.



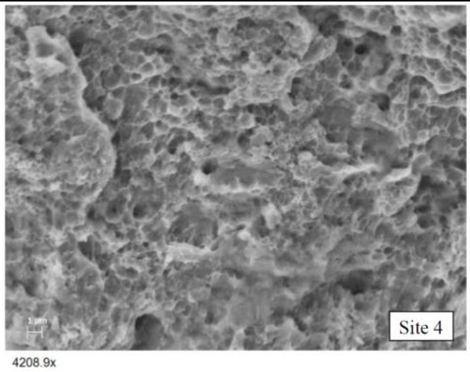
Dimple rupture fracture at area 1



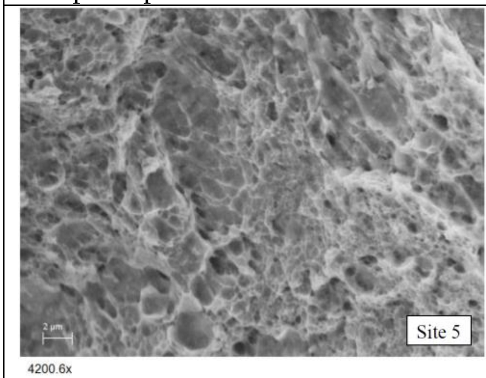
Dimple rupture fracture at area 2



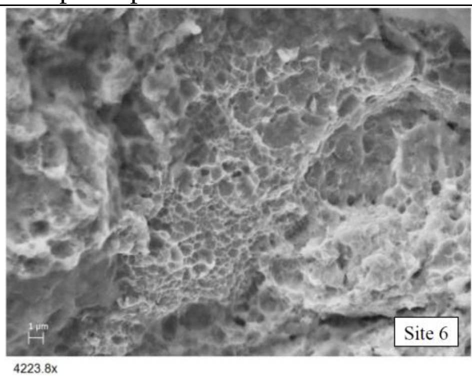
Dimple rupture fracture at area 3



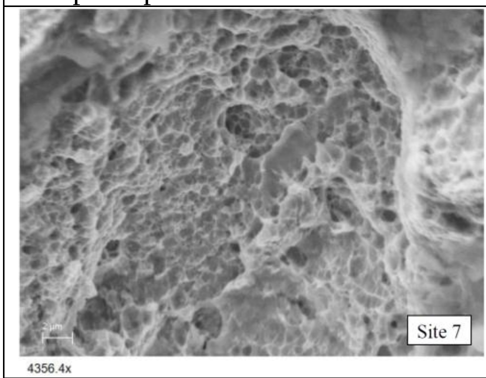
Dimple rupture fracture at area 4



Dimple rupture fracture at area 5



Dimple rupture fracture at area 6



Dimple rupture fracture at area 7

Figure 29: The Scanning Electron Microscope (SEM) result

d. All forward yoke plate arms bent between 3.01 millimeters (0.12 inch) to 14.40 millimeters (0.57 inch).

e. All arms of the forward yoke plate found seized by the trunnion pin bearing. The location of indentations made by the inboard edge of the roller bearing on the forward yoke plates corresponds to average actuator position around 13°-14° of propeller blade angle.

   In addition, the worn marks measurement revealed that the depth of the seized mark on the forward yoke plate arms between 0.16 to 0.24 millimeters and the depth of the seized mark on the aft yoke plate arms between 0.409 to 0.518 millimeters.

6. In 10 February 2015, the Propeller Manufacturer provided to the investigation related to the propeller excessive vibration and the trunnion pin retention friction.

   The report stated as follow:

   Retention Friction Observations

   - *Root Cause investigation and VSS test have identified a possible source of increased load on Blade Trunnion Pins as being a change in blade retention friction.*
     - *If a frictional build-up were to occur in the blade retention bearings, normal blade pitch change would require higher actuator force*
     - *If the friction build-up was sufficient to stall or nearly stall Blade pitch change, full Actuator force could be applied to one or more Trunnion Pins*

   Retention Friction

   - *Possible sources of retention friction*
     - *Blade Seal*
     - *Ball Bearing to Raceway rolling friction*
     - *Ball Bearing to Separator*
   - *Blade Seal*
     - *Possible friction not sufficient to stall pitch change*
       - *Seals would be destroyed if interfaces were compromised*
   - *Rolling Friction*
     - *Unlikely contributor as there has been no notable damage or wear observed on raceways*
       - *Rolling friction considered when prop components are sized*
   - *Ball Bearing to Separator*
     - *Potential for increased friction at this interface discovered during development tests of a 8-bladed propeller in early 2000's*
     - *Manifested by:*
       - *RPM flux / prop functional issues / Actuator stick-slip*
         - *Issues were observed following high 1P loading operations*

➢ *Once discovered, issues could be recreated / duplicated*

- *Analytical work developed a kinematic theory*
    - *Labeled "Ball Bunching"*
- *Increased friction issue had not been observed on any other propeller applications (including the 568F)*

The illustration of the effect of ball bunching is as follow.

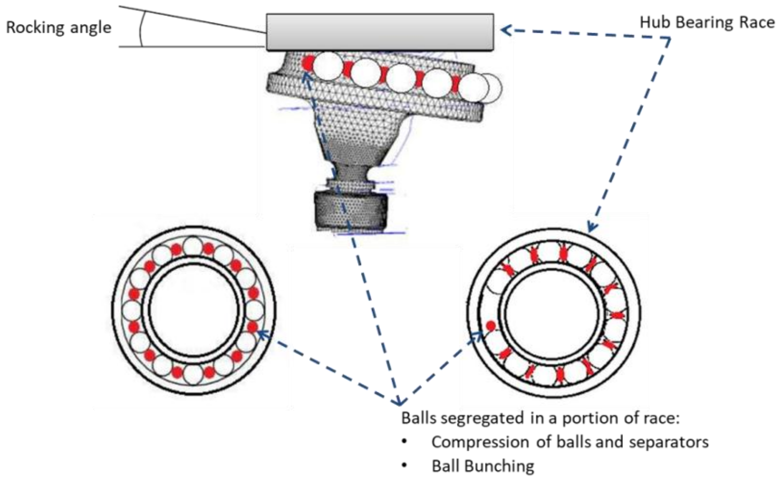


Figure 30: Ball bunching effect

1.7.3 ATR Publication, Test and Research

1. On 23 September 2014 the ATR issued Operators Information Message (OIM) number OIM 2014/010 Issue 1 (568F-l Propeller Pitch Change Mechanism Damage). The OIM, provide the recommendation to the operator for conducting the trouble shooting initiated by the PEC FAULT legend is illuminated during flight phase associated with high and sudden vibrations. The troubleshooting referred to Propeller Manufacturer Service Bulletin number SB568F-61-67 (Propeller Actuator Inspection of Yoke Plate) which issued on 2 October 2014. The SB is to verify the PEC if the fault recorded code 67 or 68 in the memory in conjunction with the vibration. The operator is requested to incorporate the SB before the next flight.
2. In 23 February 2015 the ATR issued Aircraft Operator Message AOM 42/72/2015/01 Issue 1. The aim of this AOM is to inform ATR operators about occurrences of sudden appearance of severe vibration in flight which were due to propeller blade angle change mechanism damage.

   The ATR recommends to operators of ATR models 42-400, 42-500 and 72-212A, to ensure that the pilots are properly informed about this type of occurrences and report any unusual and sudden vibrations similar to the ones described in this AOM. ATR also recommends that the Operation Engineering Bulletin (OEB) number 25 be inserted in the on-board operational documentation and be made readily available to all pilots.

   As for maintenance actions, ATR recommends that Propeller Manufacturer SB 568F-61-67 to be performed each time pilot report unusual vibration in descend, associated to a PEC Fault (with codes 67 & 68).

The OEB number 25 is mainly to provide the procedure to the pilot in case of vibration. The content of the OEB number 25 is as follow:

In any case, every vibration occurrence is to be reported to maintenance.

If the power lever has to be reduced to flight idle position during descent at high speed (close to VMO), it is recommended to perform a smooth and progressive power levers reduction.

IN CASE OF SUDDEN AND HIGH VIBRATIONS:

ICING CONDITIONS...CHECK

Unbalanced blade icing may also generate propeller vibrations.

In this case refer to:

- *QRH 3.21 AT FIRST INDICATION OF ICE ACCRETION procedure, or*
- *QRH 1.09 SEVERE ICING procedure*

ENG PARAMETERS ....CHECK

Check for any fluctuations of powerplant parameters that may indicate the affected engine, mainly TQ and Np. Check also for transient or steady alerts (PEC, ACW faults or any other alerts) that may be associated with powerplant vibrations and indicate the affected engine.

If affected engine cannot be identified via engine parameters, flight crew should move one PL at a time: it may help to determine the affected side, as the vibrations level and frequency may change with PL position.

▪ *IF AFFECTED ENGINE IS IDENTIFIED*

PL affected eng... FI

CL affected eng... FTR THEN FUEL SO

LAND ASAP

SINGLE ENG OPERATION procedure (2.04).... APPLY

▪ *IF AFFECTED ENGINE CANNOT BE IDENTIFIED*

PL 2 .... FI

CL 2... FTR

▪ *IF VIBRATIONS SIGNIFICANTLY CHANGE*

Engine 2 failure is suspected and should be shut down

CL 2... FUEL SO

LAND ASAP

SINGLE ENG OPERATION procedure (2.04)............ APPLY

▪ *IF VIBRATIONS PERSIST*

Restore engine 2 and same check repeated on engine 1

CL 2 .... AUTO

PL 2 .... AS RQRD

PL 1 .... FI

CL 1 .... FTR

▪ *IF VIBRATIONS SIGNIFICANTLY CHANGE*

Engine 1 failure is suspected and should be shut down

CL 1.. FUEL SO

LAND ASAP

SINGLE ENG OPERATION procedure (2.04).............. APPLY

1.7.4 Examination of the Audio (CVR) Data by Bureau d'Enquêtes et d’Analyses (BEA)

On 10 December 2013, based on the audio recorded in the CVR that contain the vibration occurrence, BEA provided the spectrum analysis report.

The spectrum analysis was used to determine the engine and propeller RPM during the flight and to identify any acoustic anomalies. The following spectrum overview shows the assigned frequency behavior associated to the sequence of audio events.

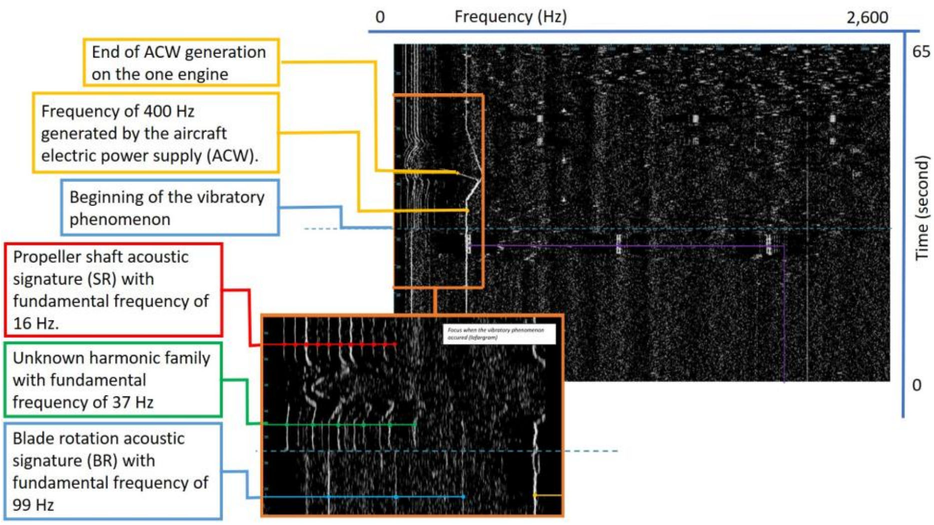


Figure 31: Spectrum analysis during the vibration

The spectrum analysis showed a harmonic family with a fundamental frequency of 99 Hz. This family was associated with the acoustic signature of the blade rotation (BR) and corresponds to an engine RPM of 82 % of the nominal rate.

A vibratory phenomenon occurred 32 seconds after the audio sample had started. At the same time, the blade rotation acoustic signature disappeared and an unknown harmonic family with fundamental frequency of 37 Hz appeared. This family was recorded for 8 seconds.

The overspeed warning was triggered just before the start of the vibratory phenomenon.

The aircraft electric power (AC Wild) supplied by the propeller reduction gearbox on each engine generates a characteristic frequency of 400 Hz. Electric generation from one of the engines stopped 8 seconds after the vibrations had begun.

A harmonic family with fundamental frequency of 16 Hz and related to propeller shaft rotation (Shaft Rate) appeared 16 seconds after the vibrations had started. This was probably the consequence of a failure located next to the propeller. However, the amount of data available was not sufficient to clearly identify the defective propeller part.

1.8 Additional Information

1.8.1 Similar Occurrences

During the investigation, KNKT informed several similar occurrences involving the propeller vibration of ATR72-212A. For the purposes of the occurrence comparison, this report described two occurrences that happened in Republic Trinidad and Tobago and Sweden. The reports available on https://bea.aero/uploads/tx_elydbrapports/9y-c140505.en_compressed__2_.pdf for the Republic Trinidad and Tobago case and www.havkom.se for the Sweden case.

1.8.1.1 Serious Incident ATR72-212A 9Y-TTC, Republic of Trinidad and Tobago

On 4 May 2014, the ATR 72-212A operated by Caribbean Airlines (Republic of Trinidad and Tobago) registered 9Y-TTC at top of descent to Piarco airport experienced strong vibrations in flight with right electronic propeller control warning.

In descent, the crew reduced the engine power to the minimum possible in flight, by positioning the levers in Flight Idle (FI). The speed of the aircraft was 246 kt, close to the maximum speed in operation (VMO) of 250 kt. The crew then felt strong vibrations which were followed by a warning associated with the electronic propeller control (PEC) of the right propeller.

After the flight, it was found that the drive shaft of the right engine AC wild generator had ruptured and it was replaced. A maintenance team carried out tests on the two engine/propeller assemblies. No vibration or abnormal operation was revealed.

The flight the next day proceeded normally. During the landing run, the crew reported a loud vibration noise when they moved the power levers from the flight idle to ground idle position.

Following this flight, various maintenance operations were undertaken. Three ground tests of the engine/propeller assemblies were carried out and did not reveal any abnormal operation. A component of the right propeller blade angle change mechanism (propeller valve module) was replaced. A fourth ground test was started, during which the power levers were moved to the reverse position. Vibrations appeared and the engines were immediately shut down. After the engine shutdown, the right engine propeller blades 1, 2, 5 and 6 were in the feather position while blades 3 and 4 seemed to stay in the reverse position. The findings on the disassembly of the right propeller blades included the rupture of the blade 4 trunnion pin and damage to the propeller blade actuator yoke plate.

1.8.1.2 Serious Incident ATR72-212A SE-MDB, Sweden

On 2 December 2014, the Swedish Accident Investigation Authority (Statens haverikommission – SHK) was informed that a serious incident involving an aircraft with registration SE-MDB had occurred upon approach to Visby Airport, Gotland County, Sweden on 30 November 2014 at 12.20.

The incident occurred during a scheduled flight from Bromma to Visby Sweden. The flight, which was conducted with an aircraft of model ATR-72-212A, had flight number DC929 and was operated by Braathens Regional AB. Four crew members and 51 passengers were on board.

The PIC has stated that small vibrations were felt during descend, at around 7,000 feet. The indicated speed was 250 knots and the power levers were set to idle. Subsequently the vibrations increased in intensity and the PIC reduced the rate of descend to 2,500 feet/minute.

The vibrations became so severe that the cabin crew had difficulties moving in the cabin and that there were difficulties reading the instruments in cockpit.

Information from the flight recorders shows that the left propeller was first feathered momentarily. The right propeller was feathered thereafter, after which the right engine was shut off. The flight continued with the left engine in operation. The information also reveals that the communication between the pilots did not include confirmation of which engine’s power levers were maneuvered. Several warning signals were activated during the sequence of events. The signals were not reset during the acute phase of the event.

When the PIC moved the right propeller control to feather position, the fuel lever was unable to be pushed it all the way to fuel shut-off position. The control was therefore returned to the “auto” position and then pushed back via the feather position to fuel shut-off, whereby the vibrations subsided.

The SIC explained the situation to the air traffic controller in the Visby tower and declared emergency. The air traffic controller triggered the alert signal.

The approach and landing were executed without problems.

The investigation revealed following damages:

- The eccentric trunnion pin on blade no. 2 was ruptured.
- The front propeller blade angle change actuator plate was severely bent on all six positions.
- The engine mounts had received damage from contact with metal.
- The engine's compressor housing was cracked along half of its circumference.
- The shaft of the AC generator was ruptured.

In conclusion to the serious incident, the SHK has been unable to establish the cause of the serious incident.

1.8.1.3 Summary of similar occurrences

The BEA investigation revealed that seven cases of vibration phenomena on the ATR 72-212A have been reported in the last few years before the occurrence. In almost all cases, the rupture of a trunnion pin of one of the blades and damage to the propeller blade actuator forward yoke plate were observed.

The BEA investigation has revealed the existence of alternating overloads causing damage to the yoke plates and of a final overload in one direction resulting in the rupture of the trunnion pin. It was not possible to determine the cause of these overloads and the precise chronology of the damage and vibrations. Nevertheless, several elements may have contributed to it:

- a retention friction increase caused by ball bunching;
- The loads caused by the trunnion pins striking the yoke plate arms of the yoke plate on the occurrence of cyclic loads on the forward yoke plate, when the aircraft speed was close to VMO and the power levers in the flight idle position;

The investigation also revealed that the maintenance operations carried out on 9Y-TTC following the vibration phenomena did not identify this damage.

As a result, the BEA has issued several safety recommendations to EASA and the FAA. These concern:

- continuing the analysis of the cyclic load phenomenon on the forward yoke plate revealed at flight idle and at a speed slightly above VMO in order to confirm that the ATR72-212A flight envelope provides sufficient margins to prevent this phenomenon from causing damage to the propeller blade angle change mechanism;
- continuing research in order to understand the sequence of damage to the propeller and the cause(s) of the overloads and that pending the outcome of this research, revising the ATR 72-212A manufacturer's recommended operating procedures for descent to prevent any flight between 240 and 250 kt at flight idle;
- installing vibration level indicators for each propeller‑engine assembly in the cockpits of commercial air transport aircraft equipped with turboprop engines;
- carrying out an in-depth study into the actual vibration behavior of each propeller in flight idle with speeds around VMO, during the initial certification of the propellers.

2 ANALYSIS

The investigation considered that the weather was not contributed to the occurrence. The analysis will discuss the issue related to the aircraft vibration and the cause of the trunnion pin failure.

2.1 In Flight Vibration

The aircraft departed from Kendari at 2339 UTC and there was no aircraft abnormality during the flight until the aircraft commenced descend.

The aircraft descended from altitude of 12,000 feet with the autopilot was engaged in vertical speed mode (VS mode) for vertical profile and the aircraft speed was increasing from 206 knots to 238 knots.

At 00:22:25 UTC, when the aircraft on descent passing altitude of about 6,000 feet the aircraft vibration started while the aircraft speed was 238 knots. At this time the rate of descent was 2,130 feet/minute (the vertical speed selection on the Auto Flight Control System (AFCS) was 2,000 feet/minute). This aircraft speed was conformed to the FCOM descent configuration however the rate of descent was not consistently maintained.

Six seconds after the initial vibration, the CVR recorded the overspeed warning indicated that the aircraft speed exceeded the maximum maneuvering speed (VMO) of 250 knots. This consistent with the FDR data which recorded the aircraft speed reached 251 knots for 3 seconds. After the vibration occurred, the pilot might have been preoccupied with the situation and did not monitor the aircraft speed until it became overspeed.

During the vibration, at 00:22:38 UTC the FDR showed that the PEC was fault. The vibration affected the beta feedback transducer in the Propeller Valve Module (PVM) which led the PEC fault. At 00:22:47 UTC the right Alternating Current Wild (ACW) generator or generator number 2 was fault. These PEC and ACW faults were overlooked by the pilot. At 00:22:50 UTC or 25 seconds after initial vibration the autopilot disengaged.

In preparing for landing, the Makassar Director controller instructed the pilot to use Runway 03. At 00:23:01 UTC, the pilot broadcasted a distress message due to the aircraft vibration and request to use Runway 31 which was closest to the aircraft flight path but refused by the Makassar Director controller. The pilot insisted to use the Runway 31 with the reason of emergency. Eventually the Makassar Director controller approved the pilot to use the Runway 31 for landing. The PEC and ACW faults were overlooked by the pilots probably influence by the increasing workload and the communication with the Makassar Director controller.

At the time of right engine ACW generator faults, the right propeller RPM was 62%. This condition was consistent with the aircraft system in which the ACW indicated fault when the propeller RPM less than 66%. However, after the right propeller RPM recovered more than 66%, the ACW remained fault until the end of recording. By system design, the fault ACW would trigger the illumination of ELEC on the CAP and ACW GEN 2 fault.

The pilot placed the CL to the OVRD (override) one by one to determine the source of vibration without success. Apart of reducing the CL, the pilot also reduced the power lever (PL) to determine the source of vibration without success because reducing the PL will change the propeller blade angle while maintaining the constant rotational speed of propeller. These indicated that the vibration was not caused by the abnormality of the engines. The illumination of PEC fault light, the ELEC on the CAP and the ACW GEN 2 fault light should had been used by the pilot to indicate that the right propeller system in the right engine was having problem.

The pilots might have been preoccupied with the aircraft vibration and unable to identify the illumination of these lights. Confused in determining the source of the vibration had made the pilot did not shut down the right engine in flight.

After the aircraft touched down, the reverse power was applied for 6 seconds followed by the increasing all engine parameters including the Inter Turbine Temperature (ITT). Afterward the FDR recorded the right NAC OVHT warning activation. The ineffective air cooling into the right engine cowling might have increasing the temperature inside the right engine cowling to more than 170°C and activated the NAC OVHT warning light. The pilot shut down the right engine 71 seconds after the activation of the NAC OVHT warning and the vibration stopped.

After parking, the right engine propeller blades were found one propeller blade in the feather position, one propeller blade was in the negative blade angle position and the rest of the blades were in the fine position.

The Propeller Manufacturer examination in 23 October 2014 suspected that the trunnion pin of the propeller blade number 5 of the right engine had been broken inflight. The evidence of the origin of the fracture on the trunnion pin was corresponding to minimum in-flight blade angle which applied during descent in preparing for landing. The break of trunnion pin of the propeller blade number 5 during the flight led to propeller aerodynamic imbalance which generated the vibration. This condition was consistence with the pilot statement that during reducing the PL, the vibration was not disappearing because the source of the vibration was not generated by the engine. Afterward the pilot returned the PL to the previous position and maintained the aircraft speed between 210 and 220 Knots.

The aircraft vibration occurred during descend and the aircraft speed was 238 knots and afterward the aircraft speed exceeded the VMO led the aircraft experienced an overspeed. The pilot was unable to identify the source of the vibration after conducting several attempts to evaluate the condition by moving both condition levers (CL) to 100%/OVRD, however the vibrations still existed and then moved the CL back to AUTO notch. Apart of reducing the CL, the pilot also reduced the power lever (PL) to determine the source of vibration without success. The break of trunnion pin of the propeller blade number 5 led to the aerodynamic imbalance to the propeller system which resulted in the aircraft vibration.

2.2 The Failure of the Trunnion Pin

In understanding of the cause of propeller trunnion failure (break of) of the propeller blade number 5, several tests and examinations have been conducted.

The Vibration Stress Survey (VSS) was performed by the aircraft manufacturer with support from the propeller manufacturer to determine the propeller load. The VSS test showed the magnitude of the blade cyclic loads during the descent maneuvers is lower than all other phases of flight with the exception of cruise. Right propeller cyclic blade loads during transition to high aircraft descend speed were 1.3 to 2 times greater than the left propeller loads which is far below the level that would cause damage. Data from both ground and flight operation showed maximum peak trunnion loading below levels required to produce permanent deformation of the trunnion and actuator hardware. Results from this survey are consistent with the results found during the 1994/1995 certification survey.

The Propeller Manufacturer provided the investigation of the trunnion pin retention friction on 10 February 2015. In the report, it was suspected that the friction was generated during the blade root ball bearing rolls back and forth in their raceway when the propeller blade angle changes. The movement of the propeller blade angle resulted in the ball bearing bunched to the ball bearing separator which created a ball bunching phenomenon which led to the increasing of the friction. The friction in the retention would contribute to load yoke plate assembly. However, as indicate in the hysteresis loops performed during the VSS test in 2014 confirmed that the total actuator friction load in contact with the trunnion pin was far below the load required to permanently deform the trunnion pin (see The Vibration Stress Survey (VSS) in chapter 1.7.2).

The examination of trunnion pin of propeller blade number 5 under the stereo microscope showed the beach mark-like pattern which suspected a result of an over loading. The examination under the SEM showed dimple rupture characterized with the appearance of microvoids which indicated there was an extra load to the trunnion pin. The fracture analysis showed that the fracture of the trunnion pin of propeller blade number 5 was likely due to steady overload applied by the aft yoke plate during the changes of the propeller blade angle resulted in the failure to the trunnion pin.

In the normal operation during the flight, the propeller blade angle change was driven by the aft yoke plate which was normally in contact with the trunnion pin bearing. During the reverse power application, the forward yoke plate was in contact with the trunnion pin bearing to limit the propeller blade into the reverse angle. In the normal operation, the worn marks on the yoke plates would develop as the trunnion pin bearings were in contact with the yoke plates.

The average worn mark on the aft yoke arm was deeper than the forward yoke arm. This worn mark showed the evidence that the aft yoke arm frequently controlled the blade angle comparing with the forward yoke arm. Prolong operation of the actuator yoke arms would develop a groove on the surface of the actuator yoke arms. When the groove had been developed on the actuator yoke arms, the trunnion pin bearing was trapped in the groove in certain blade angle therefore more loads might be required to move the trunnion pin bearing to get out from the groove during the blade angle changes. However, the VSS test in 2014 confirmed that the total yoke arms friction load in contact with the trunnion pin was far below the load required to permanently deform the trunnion pin.

On the propeller blade number 2, it was found that the bolt to secure the trunnion pin bearing via a support plate was broken. The Propeller Manufacturer detail examination to the trunnion pin of the propeller blade number 2 showed that the forward yoke plate arm number 2 found with residual bending of 14.4 mm (0.567 in). With this amount of bending, the trunnion bearing support plate would have been in contact with the forward yoke plate when reverse power was commanded. The contact of the trunnion bearing support plate with the forward yoke plate created a shear load to the bolt which resulted in the broken of the support plate bolt.

The material test to the trunnion pin, aft and forward yoke showed in confirmation with the design specification. In addition, the sound spectrum analysis could not show the source of the load anomaly during the normal aircraft operation.

In 10 February 2015, the Propeller Manufacturer provided to the investigation related to the propeller excessive vibration and the trunnion pin retention friction. The root cause investigation and VSS test have identified a possible source of increased load on trunnion pins as being a change in blade retention friction. If a frictional build-up were to occur in the blade retention bearings, normal blade pitch change would require higher actuator force. If the friction build-up was sufficient to stall or nearly stall blade angle change, full actuator force could be applied to one or more trunnion pins.

The possible source of the retention friction includes the blade seal, ball bearing to raceway rolling friction and the ball bearing separator. The blade seal might develop the friction however the friction was not sufficient to stall the blade angle change. The ball bearing to raceway rolling friction was unlikely contribute the high friction as there was no evidence of damage or wear observed on the ball bearing or the raceways. The ball bearing separator had a potential increased the friction as the ball bearing were bunch together during the blade angle change (see The Aircraft and Propeller Manufacturer Test and Research chapter 1.7.2 point 6). This phenomenon called as ball bunching. If the ball bunching occurred there might had been an extra load during the blade angle change which led to deform the yoke plates.

In summary, the right engine propeller actuator yoke plate experienced a high load as result of ball bunching phenomenon which deformed the yoke plates and broke the trunnion pin of the propeller blade number 5. The broken trunnion pin of the propeller blade number 5 led to the vibration. After aircraft touchdown the reverse power was applied and at the same time the bolt to secure the trunnion pin bearing via a support plate of propeller blade number 2 was broken resulted in the trunnion pin of propeller blade number 2 escaped from the deformed actuator yoke plate.

3 CONCLUSIONS

3.1 Findings

Findings are statements of all significant conditions, events or circumstances in the accident sequence. The findings are significant steps in the accident sequence, but they are not always causal, or indicate deficiencies. Some findings point out the conditions that pre-existed the accident sequence, but they are usually essential to the understanding of the occurrence, usually in chronological order.

The findings of this occurrence are as follow:

1. The aircraft had a valid Certificate of Airworthiness prior to departure.
2. The pilot held current license and medical certificate.
3. There was no aircraft abnormality reported prior to departure.
4. The flight of the occurrence was the second flight from the planned of four flights of the day.
5. The PIC was the Pilot Monitoring and the SIC was the Pilot Flying.
6. The flight from the departure until descend was uneventful.
7. The aircraft descended with the autopilot was engage and the vertical profile was engaged in Vertical Speed (VS) mode while the vertical speed selection on the AFCS was -2,000 feet per minutes.
8. During the aircraft descended at the altitude approximately of 6,000 feet the aircraft experienced vibration. At this time the aircraft speed was 238 knots and the vertical speed was -2,130 feet per minutes. The PIC took over the control of the aircraft and instructed the SIC to call “mayday” to the Makassar ATS controller informing that the aircraft experienced engine problem.
9. During the aircraft vibration, the PIC moved each Condition Lever (CL) from AUTO to OVRD intended to determine the vibration source but the vibration still exist afterward the PIC placed the both CL to AUTO position. The FDR recorded the varied value of the NP for 7 seconds. The PIC also moved the Power Lever (PL) to reduce the aircraft speed but the vibration was not disappearing, afterward the PIC placed the PL at previous position. The FDR showed the difference of left and right PL for 43 seconds.
10. During the vibration, the aircraft speed reached 251 knots (over the VMo) for 3 seconds and the descent speed was 1,770 feet per minutes.
11. The autopilot disengaged 25 seconds after initial vibration.
12. The right ACW generator was indicated fault until the end of recording. The vibration probably affected the generator that led to faulty.
13. The normal propeller blade angle changes in flight mostly driven by the aft yoke plate where the trunnion pin bearing is in contact with the aft yoke plate. During the reverse power applications, the forward yoke plate is in contact

with the trunnion pin bearing to limit to the propeller blade into the reverse angle.

14. Data from both ground and flight operation showed maximum peak trunnion loading below levels required to produce permanent deformation of the trunnion and actuator hardware. Results from this survey are consistent with the results found during the 1994/1995 certification survey.

15. The hysteresis loops during the VSS provided the evidence that there was friction build up between the propeller blades root with the ball bearing during flights test. The movement of the propeller blade angle resulted in the ball bearing bunched to the ball bearing separator which created a bull bunching phenomenon which led to the increasing of the friction. The friction during the blade change might develop a load to the yoke plate assembly.

16. The fracture analysis showed that the fracture of the trunnion pin of propeller blade number 5 was likely due to steady overload applied by the aft yoke plate during the changes of the propeller blade angle resulted in the failure of the trunnion pin of the propeller blade number 5. It was likely the trunnion pin of the propeller blade number 5 was broken during aircraft descend that led to the aircraft vibration.

17. The examination of the broken trunnion pin of the propeller blade number 5 under the stereo microscope showed the beach mark-like pattern which consistent with the examination under the Scanning Electron Microscope (SEM). In addition, examination under the SEM showed an appearance of microvoids indicated there was an overload to the trunnion pin.

18. The vibration affected the beta feedback transducer in the Propeller Valve Module (PVM) which led the PEC fault.

19. The FDR recorded that after the aircraft touch down, 1 second later the reverse power was applied for 6 seconds indicated by the movement of the PL angle backward.

20. After the aircraft parked, it was found that on the propeller blade number 2, the bolt to secure the trunnion pin bearing with the trunnion support plate was broken. The propeller blade number 2 going beyond actuator forward yoke plate and interference with blade number 3 preventing the proper feathering on ground for most of the blades. The Propeller Manufacturer detail examination to the trunnion pin of the propeller blade number 2 showed that the forward yoke plate arm number 2 found with residual bending of 14.4 mm (0.567 in). With this amount of bending, the trunnion bearing support plate would have been in contact with the forward yoke plate. The contact of the trunnion support plate with the forward yoke plate created a shear load. The shear load led to the broken of the trunnion support plate which was likely the happen when reverse power was commanded.

21. The FDR recorded that after the application of reverse power, the NL (the engine low pressure compressor), NH (the engine high pressure compressor) and the Inter Turbine Temperature (ITT) of the right engine were significantly higher than the left engine. The less cooling to the right engine nacelle was

likely increasing of the right engine ITT more than 170° triggered the NAC overheat warning activation.

22. The right engine was shut down after 71 seconds later as recorded by the FDR indicated by the CLA 2 move to shut off and 10 minutes 42 seconds later the left engine shut down indicated by the left CLA 1 move to shut off.

3.2 Contributing Factors

The Contributing factors defines as actions, omissions, events, conditions, or a combination thereof, which, if eliminated, avoided or absent, would have reduced the probability of the accident or incident occurring, or mitigated the severity of the consequences of the accident or incident. The presentation is based on chronological order and not to show the degree of contribution.

Based on the investigation, the contributing factor of this occurrence is as follow:

The trunnion pin of the propeller blade number 5 was broken during aircraft descend that led to the aircraft vibration. The fracture analysis showed that the failure of the trunnion pin of propeller blade number 5 was likely due to steady overload applied by the aft yoke plate during the changes of the propeller blade angle.

4 SAFETY ACTION

At the time of issuing this draft Final Report, the KNKT had been informed of safety actions resulting from this occurrence.

4.1 PT. Wing Abadi Airline

To avoid any vibration and over speed situation the PT. Wing Abadi Airline issued Notice to Crew as follow:

Wings Air	NOTICE TO CREW	
SUBJECT : NEW SOP POLICY	Notice Number	: 04 /OMPIW/NTP/X/13
	Applicability	: ATR 72 PILOTS
	Date of Issued	: 09 October 2013
	Date of Effectiveness	: 09 October 2013
	Distribution List	: DOIW, CASO, OM

Dear Pilots,

Herewith we would like to emphasize new SOP Policy:

1. For any Flight Phase, **never to used**. Condition Lever to 100 % OVERRIDE position, except:
   - Following QRH Procedure (abnormal/emergency)
   - Following Landing Procedure at Special Airport Procedure.
2. For any Flight Phase, **never to moved** Power Lever below 10 % TQ indicator, except:
   - Following Procedure.
   - Landing Technique Procedure.
3. Maximum descend speed is 230 KTS IAS.

All procedures above effective at this date.

Best Regards,

4.2 The Aircraft Manufacturer

1. On 23 September 2014 the ATR issued Operators Information Message number OIM 2014/010 Issue 1. The OIM introduced a troubleshooting manual modification and Propeller Manufacturer issued a Service Bulletin SB568F-61-67. The SB introduce a new trouble shooting guide to the engineer in case of PEC fault light illuminated during flight phase associated with sudden and high propeller vibration and fault codes 67 and 68 stored in PEC memories.
2. On 2 October 2014, the ATR recommend to introduce the Propeller Manufacturer Service Bulletin number 568F-61-67. This bulletin gives the

instructions to measure blade angle backlash on all six blades of the 568F propeller, remove the actuator and measure the distance between the arms of the actuator forward and aft yoke plates if indicated, and return the actuator and blades for engineering investigation if necessary.

3. On 23 February 2015, the ATR issued Operation Engineering Bulletin (OEB) number 25 related to the procedure for aircraft vibration identification and handling. The ATR recommended to inserts the OEB number 25 in the on-board operational documentation and be made readily available to all pilots.

4. On 28 August 2015, the ATR recommend to incorporate the Propeller Manufacturer SB number 568F-61-69 to introduce a revised design of the ball separator. This separator has a dual pocket configuration that, through testing, was determined to reduce the build-up of retention friction. In addition, the design utilizes a material specified on other propeller applications to reduce friction. All twelve ball separators in a propeller assembly will need to be replaced to fully complete this service bulletin.

5 SAFETY RECOMMENDATIONS

The KNKT acknowledges the safety actions taken by PT. Wing Abadi Airline, the Aircraft and Propeller Manufacturers and considered that the safety actions were relevant to improve safety, therefore the KNKT is not issuing safety recommendation in this report.

6 APPENDIX

The Accredited Representatives comments

No.	Reference Chapter, Page, Paragraph	Original Text	Proposed Amendment	Reason for Proposed Change	Parties	KNKT Response
1	i	1.7.4.1 Vibration sound examination	Examination of the audio data (CVR sample that contain the vibration occurrence)		BEA	accepted
2	vi	the pilot requested to descend. At the aircraft altitude approximately of 6,000 feet, the aircraft experienced heavy vibration, but the engine instruments indicated normally	the pilot requested to descend. At the aircraft altitude approximately of 6,000 feet, the aircraft experienced heavy vibration. The PEC 2 fault together with the ACW gen 2 alerts were triggered.	clarification	BEA	accepted
3	vi	During aircraft descended the pilot noticed	During aircraft descent the pilot noticed	clarification	BEA	accepted
4	vi	The PIC was exercising the CL and PL to identify the source of vibration without successful.	To be replaced by: "The PIC tried to evaluate the condition by moving both condition levers (CL) to 100%/OVRD, however the vibrations still existed and he moved the CL back to AUTO notch"	clarification	BEA	accepted
5	vi	The aircraft approach was uneventful and at 0028 UTC (0828 LT) the aircraft landed safely on runway 31	At 0028 UTC (0828 LT) the aircraft landed runway 31	clarification	BEA	accepted
6	vi	the aircraft landed safely on runway 31.	include: "with the use of reverse on both engines"	clarification	BEA	accepted
7	vi	At the same time the vibration was disappear.	At the same time the vibration disappeared.	clarification	BEA	accepted

No.	Reference Chapter, Page, Paragraph	Original Text	Proposed Amendment	Reason for Proposed Change	Parties	KNKT Response
8	vi	in the fine position.	replace by "unfeathered"	clarification	BEA	accepted
9	vi	Afterward the engineer exposed the propeller hub found the trunnion pin was broken and the forward yoke was deformed.	Afterward the engineer removed the propeller hub found a trunnion pin was broken and the forward yoke was deformed.	clarification	BEA	accepted
10	vi	The investigation was considered the contributing factors of the occurrence was	The investigation considered that the contributing factors of the occurrence were	clarification	BEA	accepted The statement was reworded
11		The fracture analysis showed that the fracture of the trunnion pin of propeller blade number 5 most likely due to steady overload applied by the aft yoke plate during the changes of the propeller blade angle resulted in the fatigue to the trunnion pin of the propeller blade number 5.	The fracture analysis showed that the fracture of the trunnion pin of propeller blade number 5 most likely due to steady overload applied by the aft yoke plate during the changes of the propeller blade angle resulted in the failure of the trunnion pin of the propeller blade number 5.	no fatigue sign - No fatigue crack growth/striations were observed.	BEA	accepted The statement was reworded
12	vi	last chapter	indicate that the inability to feather the propeller on ground was attributed to reverse operation on ground leading one blade going beyond bent actuator plate and associated blades interferences	clarification	BEA	accepted The statement was reworded
13	vi	Manufacture	replace by "manufacturers"	clarification	BEA	accepted
14	1	but the engine instruments indicated normally	PEC fault on engine 2 and ACW gen 2 were triggered during the event.	clarification	BEA	accepted
15	2	aircraft landed safely on Runway 31.	include "with the use of reverse on both engines"	clarification	BEA	accepted
16	2	in the fine position.	unfeathered	clarification	BEA	accepted

No.	Reference Chapter, Page, Paragraph	Original Text	Proposed Amendment	Reason for Proposed Change	Parties	KNKT Response
17	2	Figure 1: The right engine propellers condition after the aircraft parked	blade 5 in feather is the one at 5 o'clock. The one showed here would be blade number 4 which is not feathered	clarification	BEA	accepted
18	10		Move box highlighting propeller blade number 5 to the lower right blade	Wrong blade is being highlighted	Collins Aerospace	accepted
19	3	The aircraft substantially damage.	Propeller system of the engine n°2 and two engine n°2 mounts were damaged	clarification	BEA	accepted
20	4	The engineer examined the right engine condition and found the engine mounting was broken as shown in the figure below.	Indicate the total number of engine mounts together with the number of mounts damaged	clarification	BEA	accepted
21	8	The PL positions are REV …	The PL can be adjusted between marked positions which are REV …	clarification	BEA	accepted
22	8	the propeller RPM (NP)	the propeller condition. Propeller speed control is managed by electronic control.	clarification	BEA	accepted
23	10	the NP is limited to 82%.	the NP is set at 82%.	clarification	BEA	accepted
24	10	Beta Scheduling	please define what Beta stands for	beta was not defined	BEA	accepted
25	Page 18 1.4.5 paragraph 5	automatically transferred to the backup channel	automatically transferred to the backup channel if the fault was detected by the primary channel.	Transfer will only happen if primary channel has the fault.	Collins Aerospace	accepted
26	Page 18 1.4.5 paragraph 6	PEC loss both channels or one of the following signals	PEC loss both channels of one of the following signals	Typo	Collins Aerospace	The sentence reworded to avoid confusing. The statement was copied from the ATR 72 System Description

No.	Reference Chapter, Page, Paragraph	Original Text	Proposed Amendment	Reason for Proposed Change	Parties	KNKT Response
						chapter 61.
27	Page 18 1.4.5 paragraph 8	will store the fault code of 67 and 68	will store the fault code of 67 or 68	Fault stored depends on which channel detected the failure	Collins Aerospace	accepted
28	12	The illustration of the propeller blade angle change is shown in the figure below.	The illustration of the propeller blade angle change mechanism is shown in the figure below.	missing word	BEA	accepted
29	12	The aft yoke plate design was thicker than the forward yoke plate therefore it will require higher load to displace.	replace displace with deform or remove sentence "The aft yoke plate design was thicker than the forward yoke plate"	displace is inappropriate	BEA	accepted
30	12	it will require higher load to displace.	it will require higher load to reach deformation.	clarification	BEA	The sentence was removed
31	20	load to displace	load to deform	Improved wording	Collins Aerospace	The sentence was removed
32	20	During the reverse power applications, the forward yoke plate is in contact with the trunnion pin bearing to drive to the propeller blade into the reverse angle.	During feathering and reverse power applications, the forward yoke plate is in contact with the trunnion pin bearing. When transitioning to reverse, the aft yoke plate drives the blades to reverse.	Improved wording	Collins Aerospace	The sentence was reworded refer to the manual of Variable Pitch Aircraft Propeller part number 815500-2/-3 and 820522-1 in chapter 61-13-12 page 8.
33	13	RPM is below 66% NP.	RPM is below 66% NP for 6 seconds or if NP drops below 52%.	clarification	BEA	accepted
34	14	The download processed was	The download process was		BEA	accepted
35	14	the serious incident flight.	clarification	the occurrence flight.	BEA	accepted
36	15	FDR Chart label Propeller 1 Beta ¾ Sign / Propeller 2 Beta ¾ Sign	Propeller 1 Low Pitch indication / Propeller 2 Low Pitch indication	Discrete indicates whether propeller blade angle is above or below the low pitch value of approximately 9 degrees Beta ¾	Collins Aerospace	accepted

No.	Reference Chapter, Page, Paragraph	Original Text	Proposed Amendment	Reason for Proposed Change	Parties	KNKT Response
				.		
37	17	At 00:22:25 UTC, the vibration started indicated by fluctuation of vertical acceleration.	At 00:22:25 UTC, fluctuation of vertical acceleration and local Angle of attacks were recorded.	except other information, impossible to be sure that the variations (that could be also due to turbulences) are due to the trunnion pin at this moment	BEA	accepted
38	17	Point 3. the propeller blade angle of the right engine moved to zero position 14 times	the propeller blade angle measurement of the right engine moved to zero position 14 times which is the expected response for a failure of the blade angle measurement system.	It was just the measurement value that went to zero – not the physical blade angle of the propeller.	Collins Aerospace	accepted
39	17	Since the vibration started until the aircraft touched down, the propeller blade angle of the right engine moved to zero position 14 times.	Propeller pitch angle started to increase from 38.7° to 40°	1st values are most likely not 0 but invalid. Other when only 1 sample drop to 0 are also most likely invalid, during <2 seconds, but can we confirm ? (EYA ??) LO pitch are not recorded at these moment, which should be the case for Beta =0	BEA	accepted
40	17	Starting from 00:22:25 UTC (when the vibration initiated), the FDR recorded the change value of both PL angles from 48° to 36° for 13 seconds, then returned to 48°. Afterward the PL angles movements were varied followed by the fluctuation of all engine parameters except the NP, until the aircraft touchdown.	At 00:22:27 UTC, acceleration started to vary. Propeller pitch of both sides was 39°, increasing. IAS was 240 kt increasing. 00:22:30 UTC, IAS reached 250kt (VMO), propeller pitch reached 40.3 on both sides and started to decrease. 00:22:32 UTC, PL moved backward to FI position, torques, NL, NH decreased. Beta	BETA invalid to be confirmed, LO pitch signal when PEC2 fault to be defined	BEA	accepted The time and statements were reworded according to the KNKT FDR data.

No.	Reference Chapter, Page, Paragraph	Original Text	Proposed Amendment	Reason for Proposed Change	Parties	KNKT Response
			propeller 1 decreased 00:22:34 UTC, NP were still close to their target 82%, beta propeller 2 became invalid (TBC) 00:22:37 UTC PEC2 was recorded FAULT during 7 seconds			
41	17	At 00:22:37 UTC, the recorded maximum vertical speed was -3,210 feet/minute while the selected vertical speed on the AFCS was -700 feet/minute. At this time the aircraft speed was 242 knots.		how was computed the vertical speed of -3210ft/min? (which is not recorded)	BEA	The vertical speed and the selected vertical speed were recorded.
42	17	At 00:22:45 UTC until 00:22:51 UTC, the left engine NP (propeller rotation) indicated 100% while and right engine 82%.	During the period 00:22:45 UTC until 00:22:51 UTC, both PL were moved forward. Beta propeller 1 increase and NP1 decreased to the target (82%) beta propeller 2 was temporarily invalid and finally was recorded increasing from a stable value around 14° toward beta propeller 1 value at 36°. Meanwhile, NP2 increased from 62% to 103% then decreased to 82%.	clarification	BEA	In the draft report, the statement was deleted to avoid confusing.
43	17	At 00:22:50 UTC, the autopilot disengaged.	addition: Beta propeller 2 was recorded invalid (recorded value of 0 without lo pich light) during 1 sample several times	clarification	BEA	Rejected because the FDR data showed that at this time, the right propeller still recorded the valid value.

No.	Reference Chapter, Page, Paragraph	Original Text	Proposed Amendment	Reason for Proposed Change	Parties	KNKT Response
44	17	At 00:27:03 UTC the aircraft touch down. One second later, the PL angle moved backward for 6 seconds indicated the selection of propeller angle to reverse. The FDR recorded that after the application of reverse, while the PL of both engines at the same position, the NL (the engine low pressure compressor), NH (the engine high pressure compressor) and EGT (the engine exhaust gas temperature) of the right engine were significantly higher than the left engine.	addition, pbeta propeller 1 and 2 decreased to -14° (expected max reverse beta) modify EGT by ITT (interturbine temperature)	clarification	BEA	accepted
45	17	From 00:27:43 UTC until the end of the recording, the right engine NP value was not recorded on the FDR.	propeller beta 2 started to increase from 0° to 28°. The recorded NP value on right side decreased to 0%. PL2 was moved forward between GI and FI. NH2 remained stable at 64% (NH1 was 79%)	clarification	BEA	Rejected to avoid confusing.
46	19	00:22:24 A change in engine sound and followed by sound of warning chime. The P1 took the aircraft control from P2	Indicate the root cause of the chime (CVR of PCMCIA cart report 22)	clarification	BEA	The source Is recorded in the CVR
47	21	the Wings Air operated 57 ATR aircraft.	Wings Air operated 57 ATR aircrafts.	clarification	BEA	accepted
48	23	The stereo microscope visual inspection found indication of fatigue on the broken trunnion pin of the propeller blade number 5.	The stereo microscope visual inspection found indication of beach marks on the broken trunnion pin of the propeller blade	there was no sign of fatigue Not consistent with Collins analysis (ref. FRACTURED TRUNNION	BEA	accepted

No.	Reference Chapter, Page, Paragraph	Original Text	Proposed Amendment	Reason for Proposed Change	Parties	KNKT Response
		The inspection by Scanning Electron Microscope (SEM) confirmed the indication of fatigue.	number 5. The inspection by Scanning Electron Microscope (SEM) showed dimples, indicative of overload.	INVESTIGATION FI-14-04):: " The fracture mode for the trunnion pin was determined to be entirely dimple rupture. No fatigue crack growth/striations were observed. The distinct semielliptical bands that radiated from a single origin on the fracture surface were evidence of a progressive, or intermittent, overload to final separation. The origin location indicated that the detrimental bending load was imparted by the aft yoke plate. There was no apparent material or manufacturing deficiency with the trunnion pin section of the blade tulip. "		
49	23	The stereo microscope visual inspection found indication of fatigue on the broken trunnion pin of the propeller blade number 5. The inspection by Scanning Electron Microscope (SEM) confirmed the indication of fatigue.	The stereo microscope visual inspection found no indication of fatigue on the broken trunnion pin of the propeller blade number 5. The inspection by Scanning Electron Microscope (SEM) confirmed the indication of dimpled rupture fracture.	No fatigue was noted during the fracture examination. Overload failure as evidenced by signs of dimpled rupture fracture was seen.	Collins Aerospace	accepted
50	23	Fatigue initiation	crack initiation	clarification	BEA	accepted
51	24	Seized	Worn	Replace with more correct term	Collins Aerospace	accepted
52	24	The forward and aft yoke plate	The forward and aft yoke plate	the word "seize" is	BEA	accepted

No.	Reference Chapter, Page, Paragraph	Original Text	Proposed Amendment	Reason for Proposed Change	Parties	KNKT Response
		exhibited functioning marks (seized marks) in all of the 6 yoke plate arms.	exhibited functioning marks (wear marks) in all of the 6 yoke plate arms.	unappropriate to describe the patterns observed on the yoke plate. Use the term "wear" as per metallurgical report. To be modified each time the word seized is used.		
53	24	Based on the visual inspection, the general opinions regarding forward and aft yoke plate of the right engine …	Based on the visual inspection, observations regarding forward and aft yoke plate of the right engine …	clarification	BEA	accepted
54	24	The seized marks on the aft yoke plate were caused by high load during the propeller blade angle changes	Examinations and researches do not corroborate this analysis: to be removed. Marks on the aft yoke plate is typical wear attributed to normal roling contact between roller and plate, without any specific high loading. What could be written is that broken trunnion pin and bent fwd yoke plates confirm the existence of an overload whose origin could not be determined.	clarification	BEA	accepted
55	24	The load to change the propeller blade angle increased due to higher friction at the worn bearing seized marks on the aft yoke arms	Examinations and researches do not corroborate this analysis: To be removed.	clarification	BEA	accepted
56	24	The load to change the propeller blade angle increased due to higher friction at the worn bearing seized marks on the aft yoke arms.	The load to change the propeller blade angle increased due to higher friction at the worn bearing seized marks on the aft yoke arms but this load is not as large in	Theory is that ball bunching is the main contributor to the fractured trunnion pin – not these local wear areas on the yoke plates.	BEA	accepted

No.	Reference Chapter, Page, Paragraph	Original Text	Proposed Amendment	Reason for Proposed Change	Parties	KNKT Response
			magnitude as that theorized to be generated by blade retention ball bunching.			
57	24	United Technologies Corporation Aerospace System (UTAS)	Name changed to Collins now. Prefer "Propeller manufacturer"	clarification	BEA	accepted
58	24	the occurrence of broken propeller	the occurrence of broken blade trunnion pin	clarification	BEA	accepted
59	24	Determine if there are load differences between right and left	Determine if there are trunnion pin load differences between right and left	Be specific about load being evaluated	Collins	accepted
60	25	During flight with wings level the left side blade loads are	During flight with wings level the left side blade trunnion pin loads are	Be specific about load being evaluated	Collins Aerospace	accepted
61	25	Operating during high bank angle turns showed that the right side loads	Operating during high bank angle turns showed that the right side trunnion pin loads	Be specific about load being evaluated	Collins Aerospace	accepted
62	25	Right propeller cyclic blade loads during transition to high aircraft descend speed were 1.3 to 2 times greater than the left propeller loads	Please indicate also that "the magnitude of the blade cyclic loads during these decent maneuvers is lower than all other phases of flight with the exception of cruise."	clarification	BEA	accepted
63	25	1.3 to 2 times greater than the left propeller loads.	1.3 to 2 times greater than the left propeller loads but still far below the level that would cause damage.	Be specific about load being evaluated	Collins Aerospace	accepted
64	25	Reverse operation was the only operating condition where test data confirmed the front actuator plate was loaded.	Reverse operation and feather were the only operating conditions where test data confirmed the front actuator plate was loaded.	Correct statement	Collins Aerospace	accepted
65	26	Loops show that friction is	Loops show that friction is	Correct statement	Collins	accepted

No.	Reference Chapter, Page, Paragraph	Original Text	Proposed Amendment	Reason for Proposed Change	Parties	KNKT Response
		released after propellers are shut down	released after engines are shut down and propellers stop rotating.		Aerospace	
66		in the propeller blade angle change system	in the propeller blade retention system	Increased friction is theorized to come from the retention bearing	Collins Aerospace	accepted
67		First flight test results gave a trend that the right engine propeller had higher actuator friction	First flight test results gave a trend that the right engine propeller had higher blade retention friction	Increased friction is theorized to come from the retention bearing	Collins Aerospace	accepted
68	27	seized	worn		Collins Aerospace	accepted
69	27	The seized on the yoke plate was caused by the high blade twisting moment.	To be removed since not supported by examination or researches.	clarification	BEA	accepted
70	27	Seizing (title in the figure 24)	Wear		Collins Aerospace	accepted
71	27	seized	to be replaced by "wear" marks	clarification	BEA	accepted
72	27	propeller counterweight …	propeller blade counterweight …	clarification	BEA	accepted The statement was deleted because not relevant
73	27	blade steady aerodynamic …	blade "steady and cyclic" aerodynamic …	clarification	BEA	accepted The statement was deleted because not relevant
74	27	The only time the trunnion pin bearing in contact with …	The only time the trunnion pin bearing in permanent contact with …	clarification	BEA	accepted
75	27	load required to plastic deformation of the forward yoke plate was about 3,500 lbf (1,500 daN)	Data to be crosschecked by Collins. Loads to bend forward plate is 3000 daN (6750 lbf)	clarification	BEA	accepted

No.	Reference Chapter, Page, Paragraph	Original Text	Proposed Amendment	Reason for Proposed Change	Parties	KNKT Response
76	27	yoke plate was about 3,500 lbf (1,500 daN)	yoke plate was about 3,000 daN (6750 lbf)	Corrected value	Collins Aerospace	accepted
77	29	corresponding with the angle approximately of 13°	corresponding with the angle approximately of 13° relative to the red dashed line corresponding to a ¾ radius propeller blade angle of approximately 39°	Correct to reference frame of propeller blade angle measurement	Collins Aerospace	accepted
78	29	The stereo microscopic and the SEM examination showed the same indication of fatigue fracture to the trunnion pin. The SEM result is as follow:	to be modified accordingly.	cf. previous comment - no fatigue was observed.	BEA	accepted
79		The stereo microscopic and the SEM examination showed the same indication of fatigue fracture to the trunnion pin. The SEM result is as follow:	The stereo microscopic and the SEM examination showed the same indication of dimpled rupture (overload) fracture to the trunnion pin. The SEM result is as follow:	Correct mode of fracture	Collins Aerospace	accepted
80	31	Seize	Worn		Collins Aerospace	accepted
81	31	The location of the seized on the forward yoke plates corresponds to average actuator position around 13°-14° of propeller blade angle.	The location of indentations made by the inboard edge of the roller bearing on the forward yoke plates corresponds to average actuator position around 13°-14° of propeller blade angle.	Report RF-DSC-848-13 section 7 wording	Collins Aerospace	accepted
82	31	It was also found that the trunnion pin had displaced between 1 to 2.4 millimeters.	Which Trunnion Pin? To be specified	clarification	BEA	deleted
83	31	Retention friction observations	Retention friction observations may be removed from factual part	report organization	BEA	The result of the test and research are part

No.	Reference Chapter, Page, Paragraph	Original Text	Proposed Amendment	Reason for Proposed Change	Parties	KNKT Response
			of the report. Would potentially fall into analysis part.			of the factual. Therefore the statements will be included in the factual information
84	35	1.7.4.1 Vibration sound examination	1.7.4.1 Examination of the audio data (CVR sample that contain the vibration occurrence)		BEA	accepted
85	35	BEA provided the investigation of vibration sound examination	BEA provided the spectrum analysis report		BEA	accepted
86	35	The vibration sound examination is to determine the engine and propeller RPM during the flight and identify any acoustic anomalies utilizing the spectrum analysis.	The spectrum analysis was used to determine the engine and propeller RPM during the flight and to identify any acoustic anomalies.		BEA	accepted
87	35	The spectrum analysis is as follow:	The following spectrum overview shows the assigned frequency behavior associated to the sequence of audio events :		BEA	accepted
88	35	This was probably the consequence of a failure located next to the propeller. However, the amount of data available was not sufficient to clearly identify the defective propeller part.				The result of the test and research is a factual information.
89	37-38	"On 30 November 2014, a similar new incident occurred in Sweden to an ATR 72-212A registered SE-MDB, for which an investigation was opened by the	to be displaced in the previous paragraph which deals with the SE-MDB event.	this paragraph deals with the 9Y-TTC event.	BEA	accepted

No.	Reference Chapter, Page, Paragraph	Original Text	Proposed Amendment	Reason for Proposed Change	Parties	KNKT Response
		Swedish investigation authority, SHK. Shortly after this incident, the BEA issued four safety recommendations to EASA in order that it, in particular [...] At the end of the investigation into the incident of 30 November 2014, the SHK issued a safety recommendation to EASA, asking that it "Consider[s] introducing temporary limitations in the maneuvering envelope, or limitations of the power ranges within the latter, until the problem is resolved and rectified."				
90	38	a retention force caused by ball bunching;	a retention friction increase caused by ball bunching;	Technically a friction rather than a force	Collins Aerospace	accepted
91	38	significant loads caused by the trunnion pins striking the yoke plate arms	~~significant~~ loads caused by the trunnion pins striking the yoke plate arms	When close to VMO, the anticipated loads on the actuator are very close to zero so the word "significant" may not apply	Collins Aerospace	accepted
92	38	unplanned operation of the control loop of the propeller blade angle change mechanism affected by forward yoke plate cyclic loading and friction.	~~unplanned operation of the control loop of the propeller blade angle change mechanism affected by forward yoke plate cyclic loading and friction~~.	This is a point of disagreement between Collins Aerospace and the BEA. Collins proposes to delete this statement as we do not believe its contribution is significant	Collins Aerospace	accepted
93	40	The investigation found that the communication between the pilot and the ATC was performed		We suggest you add a chapter regarding ATC management of the event It has been noticed	BEA	

No.	Reference Chapter, Page, Paragraph	Original Text	Proposed Amendment	Reason for Proposed Change	Parties	KNKT Response
		normally along the flight		during several events that the ATC request added workload in the flight deck. The fact that the ATC refused twice the request to change the runway could be further expanded		
94	40	In the descent phase, placing the CL to OVRD position will not affected significantly to the propeller RPM because during the descent, the procedure required the pilot to set PWR MGT on the takeoff selection in which the propeller rotation speed will be 100% RPM	In the descent phase, placing the CL to OVRD position will not affected significantly to the propeller RPM if it is already at 100% based on some other control setting.	ATR aircraft incorporate a memory function to remain at 82% propeller speed on approach unless the power lever is moved to a high power position (for go-around).	Collins Aerospace	The statement was deleted to avoid erroneous.
95	40	did not see any indication of abnormal engine indications.	PEC fault and ACW gen 2 fault to be mentioned	clarification	BEA	accepted
96	40	the procedure required the pilot to set PWR MGT on the takeoff selection in which the propeller rotation speed will be 100% RPM.	To be corrected: in flight, setting PWR MGT to T/O position will not drive to 100% NP. NP will be maintained at 82% if not in Beta mode and would be commanded to 100% in case of go-around when PLA are set on TO position.	clarification	BEA	The statement was deleted to avoid erroneous.
97	40	… to the fine blade angle which applied ...	minimum in-flight blade angle would be more accurate. "fine pitch" may imply low pitch condition which was not the case.	clarification	BEA	accepted
98	40	The broken of the trunnion pin	The break of the trunnion pin	clarification	BEA	accepted
99	40	The broken of the trunnion pin	Root cause for vibration is aero imbalance due to one free blade	clarification	BEA	accepted

No.	Reference Chapter, Page, Paragraph	Original Text	Proposed Amendment	Reason for Proposed Change	Parties	KNKT Response
			and associated blade-to-blade pitch difference.			
100	40	in which the ACW will indicated fault	in which the ACW indicates fault	clarification	BEA	accepted
101	40	corresponding to the angle of 13°-14°	corresponding to the angle of 39°-40°	Converted to ¾ radius blade angle convention	Collins Aerospace	Replaced by "minimum in-flight blade angle"
102	41	illumination of these lights	illumination of these lights "and of the PEC fault light"	clarification	BEA	accepted
103	41	Exhaust Gas Temperature (EGT)	fact to sustain the analysis ? Pilot statements ?	clarification	BEA	The statement was reworded
104	41	after conducting several attempt	attempts to evaluate the condition by moving both condition levers (CL) to 100%/OVRD, however the vibrations still existed and he moved the CL back to AUTO notch.	clarification	BEA	accepted
105	41	The vibration caused by the propeller blade number 5 of the right engine could not be controlled due to the broken trunnion pin	Sentence already in previous paragraph. Suggestion to remove	clarification	BEA	This statement in the last paragraph is part of the summary of what happen and the identification of the vibration source.
106	41	Most probably, after the trunnion pin of the propeller blade number 5 was broken, the blade angle signal lost and the PEC unable to control the propeller blade angle	Most probably, after the trunnion pin of the propeller blade number 5 was broken, the blade angle signal lost and the PEC unable to measure the propeller blade angle	Still able to control propeller speed but momentarily unable to measure blade angle	Collins Aerospace	accepted The statements was reworded.
107	42	blade angle momentarily.	~~blade angle~~ momentarily.	"blade angle" repeated from bottom of previous page	Collins Aerospace	accepted
108	42	The Vibration Stress Survey (VSS) was performed by the	The Vibration Stress Survey (VSS) was performed by the	Testing accomplished by Collins and ATR	Collins Aerospace	accepted

No.	Reference Chapter, Page, Paragraph	Original Text	Proposed Amendment	Reason for Proposed Change	Parties	KNKT Response
		propeller manufacturer to determine	aircraft and propeller manufacturers to determine			
109	42	by the propeller manufacturer	performed by the aircraft manufacturer with support from the propeller manufacturer	clarification	BEA	accepted
110	42	The VSS test showed that the right propeller cyclic blade loads during transition to high aircraft descend speed were 1.3 to 2 times greater than the left propeller loads.	You may indicate that the magnitude of the blade cyclic loads during these decent maneuvers is lower than all other phases of flight with the exception of cruise.	clarification	BEA	accepted
111	42	However, the manufacture stated that the VSS test phenomenon of the blade load was similar to the data during certification.	Suggest rewording since Propeller manufacturer position on VSS results is as follows: "Data from both ground and flight operation showed maximum peak trunnion loading below levels required to produce permanent deformation of the trunnion and actuator hardware. Results from this survey are consistent with the results found during the 1994/1995 certification survey;"	clarification	BEA	accepted
112	42	The load might influencing to the deformation of the forward yoke plate, seizing marks on the actuator yoke plate arms and the broken trunnion pins of propeller blade number 5	Consider reformulating, Friction in the retention would contribute to load yoke plate assy. However, and as indicated in the report, the hysteresis loops performed during the VSS tests in 2014 confirmed that associated loads, corresponding to a friction build-	clarification	BEA	accepted Reworded the statement to simplified the reader understanding

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			up, were in the region of 370 daN i.e., 15 % of the static load required to permanently deform the trunnion pin or the forward yoke plate ears. "Seizing" marks on the actuator yoke plate arms correspond to wear marks resulting from rolling contact and not overload.			
113	42	seized or seizing	wear	Improved wording	Collins Aerospace	accepted
114	42	The fracture analysis showed that the fracture of the trunnion pin of propeller blade number 5 most likely due to steady overload applied by the aft yoke plate during the changes of the propeller blade angle resulted in the fatigue to the trunnion pin.	to be modified accordingly.	clarification	BEA	the statement had been deleted
115		The fracture analysis showed that the fracture of the trunnion pin of propeller blade number 5 most likely due to steady overload applied by the aft yoke plate during the changes of the propeller blade angle resulted in the fatigue to the trunnion pin.	The fracture analysis showed that the fracture of the trunnion pin of propeller blade number 5 most likely due to steady overload applied by the aft yoke plate during the changes of the propeller blade angle resulted in the failure to the trunnion pin.	No fatigue was observed	Collins Aerospace	the statement had been deleted
116	42	During the reverse power applications, the forward yoke plate is in contact with the trunnion pin bearing to drive to	During the reverse power applications, the forward yoke plate is in contact with the trunnion pin bearing to limit to the	Blades are driven into reverse using the aft yoke plate	Collins Aerospace	accepted

No.	Reference Chapter, Page, Paragraph	Original Text	Proposed Amendment	Reason for Proposed Change	Parties	KNKT Response
		the propeller blade into the reverse angle.	propeller blade into the reverse angle.			
117	42	The movement of the trunnion pin bearing on the actuator yoke plate arm with an extra load would develop seized mark to the yoke plate arm	No evidence of such a statement, to be removed.	clarification	BEA	accepted
118	42	When the groove had been developed on the actuator yoke arms, the trunnion pin bearing was trapped in the groove in certain blade angle therefore more loads might be required to move the trunnion pin bearing to get out from the groove during the blade angle changes.	When the groove had been developed on the actuator yoke arms, the trunnion pin bearing was trapped in the groove in certain blade angle therefore more loads might be required to move the trunnion pin bearing to get out from the groove during the blade angle changes but this load is insignificant compared to the load necessary to damage the trunnion pin.	Calculations have shown that this load is far from the load level needed to damage the trunnion pin.	Collins Aerospace	accepted
119	42	The seized mark on forward and aft yoke plates, the deformation of the forward yoke and the broken trunnion pin showed the evidence of the extra load being applied to the propeller actuating system	Wear marks are not evidence of extra loading: to be removed.	clarification	BEA	accepted
120		seized	wear	Improved wording	Collins Aerospace	accepted
121	43	power was applied and at the same time the bolt to secure the trunnion pin bearing via a support plate was broken	broken support plate is the result from reverse application: direct correlation to be made between both.	clarification	BEA	The paragraph had been reworded.

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122	43	The examination to the broken trunnion pin of the propeller blade number 5 revealed a fatigue indication	to be modified accordingly.	clarification	BEA	The paragraph had been reworded.
123	43	The broken trunnion pin, the seized mark on the aft yoke arms, the seized mark on the forward yoke arms and the deformation of the forward yoke might indicate there was an extra load in the propeller actuator system however the source of the extra load could not be determined.	Repetition of the same sentence. Same comment applies: wear marks are not an evidence of extra loading: to be removed.	clarification	BEA	The paragraph had been reworded.
124	43		we suggest you add a paragraph regarding operational analysis	report completion	BEA	The operational analysis had been described in chapter 2.1.
125	45	… during the level flight the left propeller blade …	… in level flight the left propeller blade …	clarification	BEA	accepted
126	45	13. During the reverse power applications, the forward yoke plate is in contact with the trunnion pin bearing to drive to the propeller blade into the reverse angle.	During the reverse power applications, the forward yoke plate is in contact with the trunnion pin bearing to limit to the propeller blade into the reverse angle.	Blades are driven into reverse using the aft yoke plate	Collins Aerospace	accepted
127	45	14. during the extreme bank the blade load of the right propeller higher 1.3 - 2 times comparing with the left propeller. The manufacture stated that the phenomenon of the blade load was	You may indicate that Propeller manufacturer position on VSS results is as follows: "Data from both ground and flight operation showed maximum peak trunnion loading below levels required to	clarification	BEA	accepted The statement was reworded

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		similar to the data during certification.	produce permanent deformation of the trunnion and actuator hardware. Results from this survey are consistent with the results found during the 1994/1995 certification survey;"			
128	45	16. The fracture analysis showed that the fracture of the trunnion pin of propeller blade number 5 most likely due to steady overload applied by the aft yoke plate during the changes of the propeller blade angle resulted in the fatigue to the trunnion pin of the propeller blade number 5. Most likely the trunnion pin of the propeller blade number 5 was broken during aircraft descend that led to the aircraft vibration.	16. The fracture analysis showed that the fracture of the trunnion pin of propeller blade number 5 most likely due to steady overload applied by the aft yoke plate during the changes of the propeller blade angle resulted in the **failure of** the trunnion pin of the propeller blade number 5. Most likely the trunnion pin of the propeller blade number 5 was broken during aircraft descend that led to the aircraft vibration.	cf. previous comment - no fatigue was observed.	BEA	accepted
129	45	16. … changes of the propeller blade angle resulted in the fatigue to the trunnion pin of the propeller blade number 5.	… changes of the propeller blade angle resulted in the fracture of the trunnion pin of the propeller blade number 5.	No fatigue	Collins Aerospace	accepted
130	45	17. … there was an extra load to the trunnion pin	there was an overload of the trunnion pin	Improved wording suggestion	Collins Aerospace	accepted
131	45	18. The broken trunnion pin of the propeller blade number 5 led to the inability PEC to control the propeller blade angle momentarily. The inability of PEC to control the propeller blade	Erroneous statement to be corrected: The speed governing control algorithm used by the PEC in flight can operate without sensed blade angle value available. Therefore, PEC speed	clarification	BEA	accepted The statement had been reworded

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		angle resulted in the right PEC indicated fault for 7 seconds then back to normal.	governing was still active, even though the PEC light was illuminated in the cockpit. Based on investigations, PEC fault was most likely attributed to vibration affecting the Beta feedback transducer in the PVM.			
132	45	18. The broken trunnion pin of the propeller blade number 5 led to the inability PEC to control the propeller blade angle momentarily. The inability of PEC to control the propeller blade angle resulted in the right PEC indicated fault for 7 seconds then back to normal.	The broken trunnion pin of the propeller blade number 5 led to the inability PEC to measure the propeller blade angle momentarily. The inability of PEC to measure the propeller blade angle resulted in the right PEC indicated fault for 7 seconds then back to normal.	clarification	Collins Aerospace	accepted The statement had been reworded.
133	45	After the aircraft parked, it was found that on the propeller blade number 2, the bolt to secure the trunnion pin bearing with the trunnion support plate was broken. The UTAS detail examination to the trunnion pin of the propeller blade number 2 showed that the forward yoke plate arm number 2 found with residual bending of 14.4 mm (0.567 in). With this amount of bending, the trunnion bearing support plate would have been in contact with the forward yoke plate. The contact of the trunnion support plate with the	Please include the correlation between blade number 2 going beyond actuator forward yoke plate and interference with blade number 3 preventing the proper feathering on ground for most of the blades.	clarification	BEA	accepted

No.	Reference Chapter, Page, Paragraph	Original Text	Proposed Amendment	Reason for Proposed Change	Parties	KNKT Response
		forward yoke plate created a shear load. The shear load led to the broken of the trunnion support plate which most likely the happen when reverse power was commanded.				
134	45	EGT	ITT	clarification	BEA	accepted
135	45	The less cooling to the right engine nacelle most likely increasing of the right engine EGT more than 170° triggered the NAC overheat warning activation	Cf. previous comments. Both effects to be decorrelated since one is internal to the engine and the other corresponds to nacelle temperature	clarification	BEA	rejected The heat convection from the engine core may affect the external environment including the engine cowling,
136	46	The fracture analysis showed that the fracture of the trunnion pin of propeller blade number 5 most likely due to steady overload applied by the aft yoke plate during the changes of the propeller blade angle resulted in the fatigue to the trunnion pin of the propeller blade number 5.	The fracture analysis showed that the fracture of the trunnion pin of propeller blade number 5 most likely due to steady overload applied by the aft yoke plate during the changes of the propeller blade angle resulted in the **failure of** the trunnion pin of the propeller blade number 5.	cf. previous comment - no fatigue was observed.	BEA	accepted
137	46	The fracture analysis showed that the fracture of the trunnion pin of propeller blade number 5 most likely due to steady overload applied by the aft yoke plate during the changes of the propeller blade angle resulted in the fatigue to the trunnion pin of	The fracture analysis showed that the fracture of the trunnion pin of propeller blade number 5 most likely due to steady overload applied by the aft yoke plate during the changes of the propeller blade angle resulted in the failure of the trunnion pin of	No fatigue	Collins Aerospace	accepted

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		the propeller blade number 5.	the propeller blade number 5.			
138	48	procedure handling the vibration in flight	replace by "procedure for aircraft vibration identification and handling"	clarification	BEA	accepted
139	48	In addition, the design utilizes a material specified on more current separators.	In addition, the design utilizes a material specified on other propeller applications to reduce friction.	clarification	Collins Aerospace	accepted
140	49	the aircraft manufacturer	the aircraft and propeller manufacturers	clarification	BEA	accepted

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