FINAL REPORT

Accident involving
Philippines American Life Insurance Company Incorporated
Beech Super King Air 300
Registration RP-C1587
at Seletar Airport, Singapore
on 19 October 2000

MOT/CA/RP-C1587
Ministry of Transport
Singapore

13 June 2003

PREAMBLE

This investigation report is on an accident involving the collapse of the left main landing gear of a Raytheon Aircraft Company Beech Super King Air 300, registration mark RP-C1587 operated by the Philippines American Life Insurance Company Incorporated, at the Seletar Airport on 19 October 2000. This report has been prepared based on the investigation carried out by the Singapore Ministry of Transport (then known as the Ministry of Communication and Information Technology) in accordance with Annex 13 to the Convention on International Civil Aviation and the Singapore Air Navigation (Investigation of Accident) Regulations. In accordance with Annex 13, the sole objective of the investigation is the prevention of accidents and incidents. It is not the purpose of the investigation to apportion blame or liability.

The then Ministry of Communication and Information Technology (MCIT) was notified of the accident on 19 October 2000 at 1630hrs. MCIT notified the Philippines Air Transportation Office (ATO) and the National Transportation Safety Board (NTSB) of the United States of the accident on 20 October 2000. An accredited representative from ATO arrived in Singapore on 21 October 2000 to participate in the investigation.

MINISTRY OF TRANSPORT
SINGAPORE

SYNOPSIS

On 19 October 2000, at approximately 1625 local time, a Raytheon Aircraft Company Beech Super King Air 300, registration mark RP-C1587 operated by the Philippines American Life Insurance Company Incorporated (PHILAM), suffered a left main landing gear failure during landing at Seletar Airport, Singapore.

There was no fire. There was no injury to the crew and persons on board the aircraft. Apart from damage to the left main landing gear, the aircraft also sustained damage to the left wing tip, left trailing edge flaps and left engine propeller blades during the landing.

The aircraft was undergoing an acceptance test flight after maintenance when the crew encountered difficulties in retracting the left main landing gear. The crew decided to return to the airport. The left main landing gear collapsed during the landing. The gear collapsed because it was not locked. The gear was not able to be locked because of the failure of an actuator clevis that formed part of the landing gear drag link assembly.

TABLE OF CONTENTS

GLOSSARY

ATO	Air Transportation Office, Philippines
ATSB	Australian Transport Safety Bureau
ICAO	International Civil Aviation Organisation
PHILAM	Philippines American Life Insurance Company Incorporated
MOT	Ministry of Transport, Singapore (Previously known as Ministry of Communication and Information Technology)
NTSB	National Transportation Safety Board, United States
OEM	Original Equipment Manufacturer
UTC	Coordinated Universal Time

1 FACTUAL INFORMATION

All times quoted in this report are based on Singapore local time, which is 8 hours ahead of Coordinated Universal Time (UTC).

1.1 History of flight

1.1.1 General information

Aircraft type	: Beech Super King Air 300, serial number FL-20
Operator	: Philippines American Life Insurance Company Incorporated
State of the Operator	: Republic of the Philippines
Aircraft registration	: RP-C1587
Type of flight	: Test flight
Date and time of accident	: 19 October 2000, at about 1625 hours
Place of accident	: Seletar Airport, Singapore
Runway in use	: Runway 21
Phase of flight	: Landing
Persons on board	: 5

1.1.2 On 19 October 2000 at 1611 hours, aircraft RP-C1587 took off on Runway 21 at Seletar Airport, Singapore, for an acceptance test flight after undergoing a 5-year inspection/maintenance programme performed by a maintenance company at Seletar Airport. After take-off, the Control Tower noticed that the aircraft's left main landing gear was not retracted. The Tower informed the pilot immediately. The pilot checked and confirmed that the left main landing gear was not retracted and locked. The pilot also noticed that the landing gear circuit breaker had tripped and the red light on the landing gear control handle was illuminated.

1.1.3 The pilot reset the circuit breaker and cycled the landing gears down. However, the left main landing gear remained unlocked and the circuit breaker tripped again.

1.1.4 The pilot attempted to retract the landing gears again. The left main landing gear remained un-retracted and unlocked, and the circuit breaker tripped again. The pilot decided to carry out an emergency gear extension and return to Seletar Airport.

Upon landing on Runway 21 at 1625 hours, the left main landing gear of the aircraft collapsed and the aircraft skidded onto the grass verge on the left of the runway. There was no fire. The Airport Emergency Service responded immediately to the accident.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	Nil	Nil	Nil
Serious	Nil	Nil	Nil
Minor	Nil	Nil	Nil
None	2	3*	Nil
Total	2	3*	Nil

* There were three maintenance personnel on board.

Table A – Injuries to Persons

1.3 Damage to Aircraft

1.3.1 The aircraft sustained damage to the left main landing gear, left wing tip, left trailing edge flaps and left engine propeller blades during the landing.

1.4 **Other Damage**

1.4.1 There was no damage to other objects or properties on the ground.

1.5 Personnel Information

1.5.1

Pilot-in-command	: Male
Age	: 51
Licence	: ATPL Licence No. 98A70
Aircraft Ratings	: KA 350, KA 90
Medical Certificate	: Valid until 26 August 2001
Instrument rating	: Valid until August 2001
Last base check	: Valid until August 2001
Last route checks	: Not applicable
Flying experience	: 8,850 hours
Duty time before accident	: 6:30 hours

1.6 Aircraft Information

1.6.1 The Beech Super King Air 300 (serial number FL-20) aircraft was imported to the Philippines from the USA (previous registration mark was N-1552Q) in September 1996. It was registered as RP-C1587 and was issued with a Republic of Philippines certificate of airworthiness in October 1996. The aircraft was operated by Philippines American Life Insurance Company Incorporated (PHILAM). The Republic of Philippines certificate of airworthiness was valid at the time of the accident.

1.6.2 Examination of the aircraft log books and maintenance records showed that the aircraft was maintained in accordance with the Beechcraft maintenance system manual, approved by the ATO. A maintenance organisation in Manila has incorporated on 10 March 1998 Raytheon's Mandatory Service Bulletin SB 2728 which required the replacement of main landing gear actuator clevis. There was no record of the details of the work performed. However, Raytheon has confirmed that the fractured clevis was a genuine part.

1.6.3 A maintenance release (final release certificate) had been issued on 19 October 2000 after the aircraft had undergone a 5-year inspection/maintenance programme at a maintenance organisation at Seletar Airport. The maintenance release was valid at the time of the accident.

1.6.4 At the time of the accident, the aircraft time in service was approximately 2,218 flight hours.

1.6.5 Examinations of the engines and propellers did not reveal any defects that could have contributed to the accident.

1.6.6 The take-off mass and the centre of gravity of the aircraft were within the specified limits.

1.7 Meteorological Information

1.7.1 The accident occurred in daylight, in good visibility and weather conditions. The reported visibility at the time of the accident was greater than 10 km and the wind strength was reported to be between 5 to 7 knots. The weather report issued by the Singapore Meteorological Service was as follows:

WSSL 190800Z 26007 KT 240V300 9999 (05) FEW020 OVC270 31/32 Q1007

WSSL 190900Z 24005 KT 210V270 9999 (05) FEW020 BKN270 30/23 Q1007

1.8 Aids to Navigation

1.8.1 The availability and use of navigation aids were not relevant to this accident.

1.9 Communications

1.9.1 Radio communications between the aircraft and Seletar Tower were normal and were not a factor in this accident.

1.10 Aerodrome Information

1.10.1 Seletar Airport has one Runway 03/21. The runway is 1,632 metres long and 46 metres wide. The runway is paved with bituminous concrete and is ungrooved. Seletar Airport is a Visual Flight Rule (VFR) airport and is installed with a 3-degree Precision Approach Path Indicator (PAPI). The runway markings provided are in accordance with the Standards and Recommended Practices (SARP) of ICAO Annex 14.

1.10.2 Aerodrome and ground facilities were not a factor in this accident.

1.11 Flight Recorders

1.11.1 The aircraft was equipped with a B & D cockpit voice recorder (CVR), part number 8904-003211 and serial number A01299.

1.11.2 The aircraft was not fitted with a flight data recorder (FDR) as it was not required under the Philippines Civil Air Regulations.

1.11.3 The contents of the CVR had no relevance to this accident.

1.12 Wreckage and Impact Information

1.12.1 The damage sustained by the aircraft was as follows:

(a) Left main landing gear actuator was broken (landing gear collapsed).
(b) Left main landing gear bay area sustained damage on impact with the ground.
(c) Left wing tip had abrasion marks on the bottom surface.
(d) Left wing trailing edge flaps found with some parts dislodged, crumpled or bent.
(e) Left engine propeller blades were damaged and curled-up at all four blade tips.

1.13 Medical and Pathological Information

1.13.1 Not applicable.

1.14 Fire

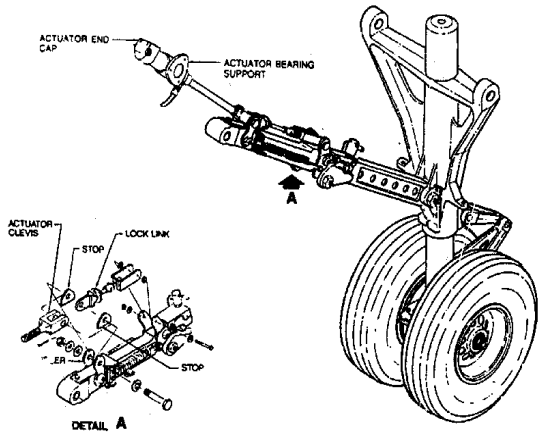
1.14.1 There was no fire.

1.15 Survival Aspects

1.15.1 All five persons onboard evacuated the aircraft safely and did not sustain any injuries.

1.16 Test and Research

1.16.1 The left main landing gear actuator clevis was found fractured. The fractured clevis and associated parts were initially sent to SETSCO Services Pte Ltd to conduct preliminary tests. Subsequently, these parts were sent to the ATSB for technical analysis to determine the nature and cause of the failure.



Left landing gear

1.16.2 SETSCO conducted visual and scanning electron microscopy examinations. ATSB conducted visual and scanning electron microscopy examinations, hardness tests, metallographic examination and fracture test. The SETSCO and ATSB reports are in Appendices A and B respectively.

1.16.3 ATSB also carried out similar tests on the clevis of the right main landing gear. There were no anomalies found.

1.17 Organisational and Management Information

1.17.1 Nil

1.18 Additional Information

1.18.1 In June 1997, Raytheon Aircraft issued a Mandatory Service Bulletin SB 2728 (See Appendix C.) requiring replacement of the clevis due to fatigue cracking in the threaded portion. The replacement actuator clevis had been strengthened to prevent fatigue cracking which was evident in the pre-modification clevis. The

FAA had also issued an Airworthiness Directive 98-21-35 on the matter covered by SB 2728.

1.18.2 From 22 July to 19 October 2000, the aircraft underwent a 5-year inspection/maintenance programme (as required in the recommended Maintenance Schedule of the manufacturer) at a maintenance organisation at Seletar Airport.

1.18.3 Maintenance records showed that the aircraft had undergone extensive checks in most areas, including the landing gears during the 5-year inspection/maintenance programme. Other than a requirement to grease the landing gear actuator clevises, the ATO-approved maintenance programme did not call for any work to be done on the clevises. However, investigation found no evidence of any greasing having been done on the clevises.

1.18.4 Investigation also found after the accident that the grease nipples on both the right and left landing gear actuator clevises have been painted over.

1.19 Useful or Effective Investigation Techniques

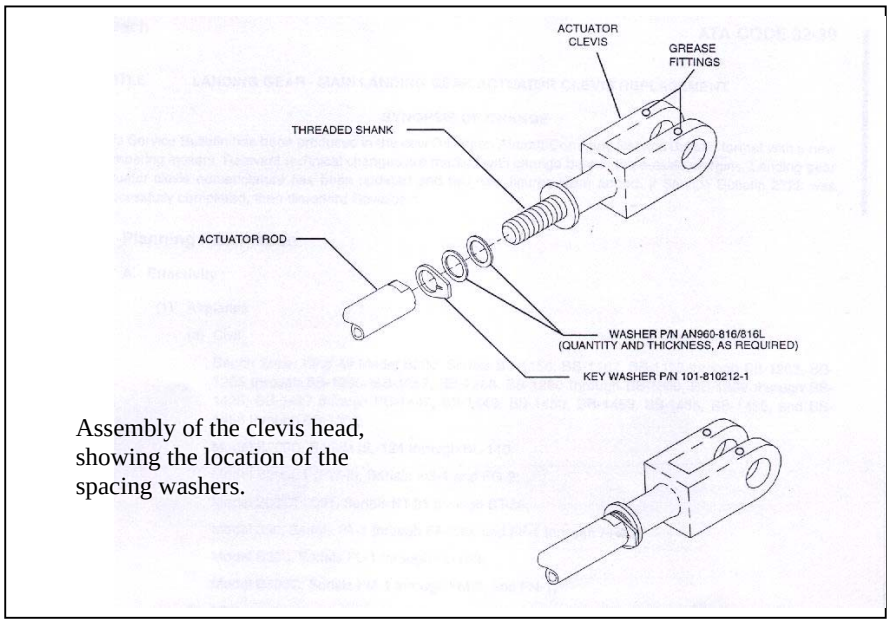
1.19.1 Not applicable

2 ANALYSIS

2.1 General

This section analyses the following aspects:-

a) Retraction of Undercarriage
b) Fractured Clevis
c) Maintenance on the Clevis
d) Maintenance at Seletar
e) Crew Actions



Assembly of the clevis head, showing the location of the spacing washers.

2.2 Retraction of Undercarriage

2.2.1 The left main landing gear could not be retracted after take-off. The pilot recycled the undercarriage twice but the left main landing gear remained extended and unlocked. It was likely that the clevis had broken when the landing gears were first retracted, resulting in the retraction problem experienced. As a result, the left main landing gear could not be locked in the extended position. The left main landing gear collapsed during landing as the landing gear was not locked.

2.3 Fractured Clevis

2.3.1 The material for the clevis as specified by the aircraft manufacturer is AISI/SAE medium alloy carbon steel. Spectrographic analysis conducted by the ATSB on the fractured clevis confirmed the clevis material.

2.3.2 The results of the ATSB examination indicated that the clevis had failed through the base of the threaded shank as a result of intergranular fracture under bending loads. There was no evidence of pre-existing cracks or other physical defects that might have contributed to the clevis' failure. Such fracturing of the clevis is abnormal and is indicative of the material having been embrittled. Poor heat-treatment control of the steel would result in embrittlement. The hardness tests conducted showed that the material had an approximate tensile strength of 236,000 psi. The maximum specified strength of the component was 200,000 psi. The material would thus have a lower than intended resistance to shock or impact loads.

2.3.3 The ATSB examinations also found no evidence of contact between the clevis and the spacing washers. The contact faces of the clevis showed no indentations, scoring or other impressions on the paint that would be indicative of washer contact. It is probable that the clevis was installed without the prerequisite number of spacing washers between the clevis head and actuator rod. Without sufficient spacing washers, high bending stresses could be produced within the clevis shank. In the presence of material embrittlement, these bending stresses could result in the brittle overload fracture as experienced in this case.

2.3.4 The above analysis indicated that the left main landing gear actuator rod had broken off at the threaded shank of the actuator clevis as a result of bending stresses causing overload fracture of an embrittled clevis.

2.4 Maintenance on the Clevis

2.4.1 In June 1997, the aircraft manufacturer issued a Mandatory Service Bulletin SB 2728 requiring replacement of the clevis due to fatigue cracking in the threaded portion with a new strengthened clevis.

2.4.2 The SB 2728 gives instructions and diagrams for installing the new design clevis. To achieve the needed clearances within the landing gear assembly, the new clevis incorporates the use of a predetermined number of washers between the end faces of the clevis and the actuator rod. When assembled and tightened to the specified torque, the assembly is rigid and reduces the degree of direct bending loads placed on the clevis shank.

2.4.3 The incorporation of SB 2728 was carried out by a maintenance organization in Manila in March 1998. However, as details of the work carried out were not documented, it is not possible to confirm whether or not the spacing washers were installed and whether there were any maintenance processes and procedures that had not been followed. Examination of maintenance records did not show any other occasion when the clevis was removed or disturbed since it was installed in March 1998.

2.5 Maintenance at Seletar

2.5.1 The aircraft had undergone a 5-year inspection/maintenance programme (as required in the recommended Maintenance Schedule of the manufacturer) at a maintenance organisation at Seletar Airport, from 22 July to 19 October 2000. The aircraft had attained 2,218 flight hours and 1,591 flight cycles.

2.5.2 Maintenance records showed that the aircraft had undergone extensive checks in most areas including the landing gears during the maintenance programme. Other than a requirement to grease the landing gear actuator clevises, the ATO-approved maintenance programme did not call for any work to be done on the clevises. Investigations showed that the landing gear clevises were not worked on or removed during the maintenance programme.

2.5.3 The investigation at the maintenance organisation at Seletar Airport also revealed that several job cards for maintenance work on this aircraft were found to have been signed off before the work was accomplished. These included two job cards that required greasing of the landing gear actuator clevis. The maintenance organisation was unable to provide a satisfactory reason for the practice. Such a practice could lead to inadvertent omission of jobs to be carried out.

2.5.4 The clevises from both main landing gears were disassembled for examination. There was no evidence that greasing had been carried out. The grease nipples were also found to have been painted over, thus blocking the hole for injecting grease to lubricate the clevis.

2.5.5 However, the lack of greasing was assessed not to have contributed to the fracture of the clevis as there is no significant evidence of surface damage and both the left and right clevis exhibit similar appearances.

2.6 Crew Actions

2.6.1 On the day of the accident, after the aircraft had taken off from Seletar Airport, the duty air traffic controller at Seletar Control Tower noticed that the left main landing gear of the aircraft did not retract. The air traffic controller immediately informed the pilot of the situation. After being notified by the air traffic controller, the pilot checked and confirmed that the left main landing gear was not retracted and locked. He also noticed that the landing gear circuit breaker had tripped and the red light on the landing gear control handle was illuminated.

2.6.2 The pilot reset the circuit breaker and cycled the landing gears down. However, the left main landing gear remained unlocked and the circuit breaker tripped again.

2.6.3 The pilot attempted to retract the landing gears again. The left main landing gear remained un-retracted and unlocked, and the circuit breaker tripped again. The pilot decided to carry out an emergency gear extension and return to Seletar Airport.

2.6.4 On landing, the crew reduced the engine power and tried to maintain an aircraft level attitude. During the landing roll, the left main landing gear collapsed and the aircraft veered to the left of the runway onto the grass verge.

2.6.5 The flight crew's actions and statements indicated that their knowledge and understanding of the aircraft systems were adequate. The actions carried out by the crew were found to be in accordance with the company's standard and abnormal operating procedures.

3 CONCLUSIONS

3.1 Findings

3.1.1 The flight crew were properly licensed, medically fit and adequately rested to operate the flight.

3.1.2 The flight crew had adequate knowledge of the aircraft systems.

3.1.3 The flight was conducted in accordance with the procedures in the company's Operations Manual.

3.1.4 The airport approach aids were operating normally at the time of the accident.

3.1.5 The aircraft had a valid certificate of airworthiness.

3.1.6 The left main landing gear collapsed because the landing gear was not locked.

3.1.7 The landing gear was not able to be locked because of a fractured actuator clevis.

3.1.8 The aircraft had undergone a 5-year inspection/maintenance programme at a maintenance organization at Seletar Airport.

3.1.9 During the maintenance programme, both the main landing gears were removed, checked and subsequently reinstalled.

3.1.10 Both the right and left landing gear clevises that were originally installed in the Philippines in March 1998 were not disturbed. No maintenance activities, other than the greasing of the clevises, were required for the clevis assembly in the five-year inspection/maintenance programme. However, greasing of the clevises was not carried out.

3.1.11 Prior to the test flight at Seletar, a satisfactory landing gear retraction test was conducted.

3.1.12 The left clevis has failed due to intergranular fracture under a bending load. The intergranular fracturing is indicative of the material having been embrittled by poor heat-treatment control during manufacturing.

3.1.13 The left clevis head had probably been installed without sufficient spacing washers, resulting in the transfer of bending loads through the shank of the component.

3.1.14 The maintenance organization that incorporated the Raytheon Mandatory Service Bulletin 2728 did not keep a record of the details of the actual work performed. As a result, it was not possible to confirm or determine the circumstances leading to the omission of the spacing washers.

3.1.15 Both clevises were found not lubricated. The grease nipples of the clevises were found painted over. However, this was assessed not to have contributed to the fracture of the clevis as there is no significant evidence of surface damage and both left and right clevis exhibit similar appearances.

3.1.16 Several job cards for the 5-year inspection/maintenance programme for this aircraft were found to have been signed off before the tasks were accomplished. The maintenance organisation that carried out the maintenance programme was unable to provide any reason for the practice.

3.1.17 The collapse of the left main landing gear during the landing was caused by the fracture of the clevis in the drag strut probably due to the transfer of landing loads to an embrittled clevis that was installed without the adequate number of spacing washers.

3.2 Contributory Factors

3.2.1 The left main landing gear collapsed because the landing gear was not locked. The landing gear was not able to be locked because the actuator clevis had fractured under bending load. The bending load was induced because of insufficient spacing washers at the clevis head. There is also evidence that the clevis was embrittled during manufacture.

4 SAFETY RECOMMENDATIONS

4.1 The aircraft manufacturer should ascertain if there are other clevis that may have been hydrogen-embrittled during manufacture and if necessary review the heat treatment process for the clevis. [AAIB Recommendation R-2003-001]

4.2 The maintenance organisation in Manila should ensure that appropriate details are kept of modifications performed on aircraft. [AAIB Recommendation R-2003-002]

4.3 The maintenance organisation in Manila should ensure that its staff perform maintenance tasks in accordance with the approved maintenance procedures. [AAIB Recommendation R-2003-003]

4.4 The maintenance organisation at Seletar Airport should ensure that its staff perform maintenance tasks in accordance with the approved maintenance procedures. [AAIB Recommendation R-2003-004]

4.5 The maintenance organisation at Seletar Airport should also ensure that its staff sign off a job card only after the task is completed. [AAIB Recommendation R-2003-005]