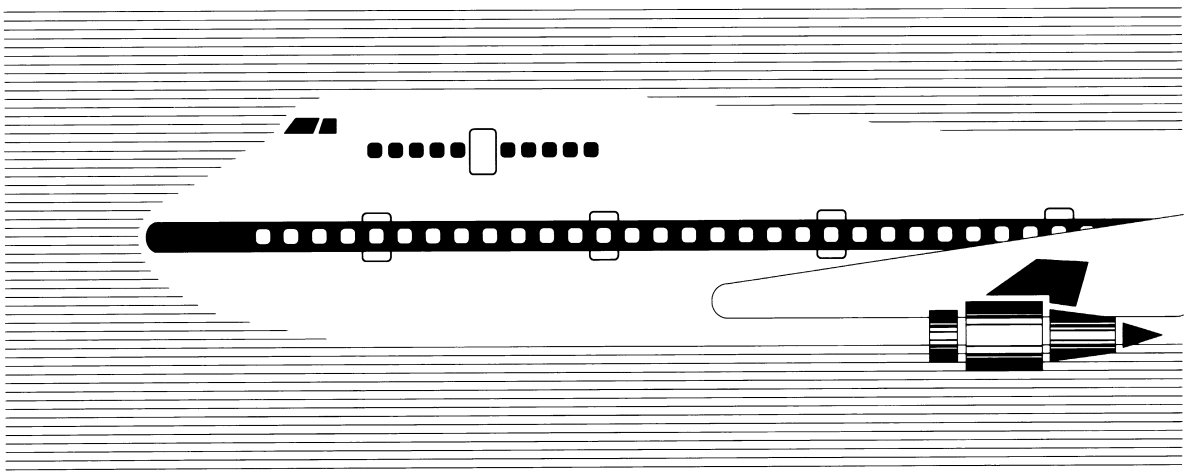
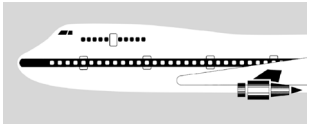
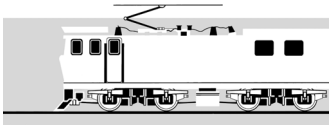


AVIATION OCCURRENCE REPORT

02-013 **Piper PA34-200T Seneca II ZK-FMW, undercarriage collapse after landing, Ardmore Aerodrome** **12 November 2002**


TRANSPORT ACCIDENT INVESTIGATION COMMISSION
NEW ZEALAND

The Transport Accident Investigation Commission is an independent Crown entity established to determine the circumstances and causes of accidents and incidents with a view to avoiding similar occurrences in the future. Accordingly it is inappropriate that reports should be used to assign fault or blame or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

The Commission may make recommendations to improve transport safety. The cost of implementing any recommendation must always be balanced against its benefits. Such analysis is a matter for the regulator and the industry.

Report 02-013

Piper PA34-200T Seneca II

ZK-FMW

undercarriage collapse after landing

Ardmore Aerodrome

12 November 2002

Abstract

On Tuesday 12 November 2002, at 2338, ZK-FMW, a Piper PA34-200T Seneca II, was returning to Ardmore Aerodrome with the pilot and 3 passengers on board. While landing on the lighted runway, the aircraft's undercarriage began to collapse. The aircraft scraped along the runway for a short distance before veering off the side of the runway and on to grass. The occupants were unhurt and vacated the aircraft unassisted. The aircraft was substantially damaged.

The cause of the undercarriage collapse was not conclusively determined, but might have been because either a transient electrical fault or play in the undercarriage assembly allowed the nose leg to move and release the downlock.

The manufacturer was aware of only one other similar incident where there was an unexplained collapse of the undercarriage. Due to the isolated nature of this incident and a lack of a confirmed cause, no new safety issue was identified.

ZK-FMW after removal from the runway area

Contents

Abbreviations

IFR	instrument flight rules
km	kilometre(s)
kt	knot(s)
m	metre(s)
UTC	coordinated universal time
VFR	visual flight rules

Data Summary

Aircraft registration:	ZK-FMW
Type and serial number:	Piper PA34-200T Seneca II, 34-8070181
Number and type of engines:	2 Teledyne Continental TSIO-360
Year of manufacture:	1980
Operator:	Christian Aviation (Trading name)
Date and time:	12 November 2002, at about 2338[1]
Location:	Ardmore Aerodrome latitude: 37° 01.8′ south longitude: 174° 58.4′ east
Type of flight:	air transport, charter
Persons on board:	crew: 1 passengers: 3
Injuries:	nil
Nature of damage:	substantial
Pilot's licence:	commercial pilot licence (aeroplane)
Pilot's age:	34
Pilot's total flying experience:	2167 hours (614 on type)
Investigator-in-charge:	I R McClelland

[1] Times in this report are New Zealand Daylight Time (UTC + 13 hours) and are expressed in the 24-hour mode.

1 Factual Information

1.1 History of the flight

1.1.1 On Tuesday 12 November 2002, ZK-FMW, a Piper PA34-200T Seneca II, was chartered to carry 3 passengers on a return flight from Ardmore with extended stopovers at Palmerston North and Napier. The pilot reported for duty at about 0730 and prepared the aircraft for the flight. He briefed the passengers and at about 0830 they departed on the first leg to Palmerston North. One passenger sat next to the pilot and the other 2 passengers sat in the rear passenger compartment. The front seat passenger remained in the same seat for each of the 3 legs.

1.1.2 The flight progressed uneventfully, landing at Napier at about 1400. The pilot and passengers reported nothing unusual during the first 2 legs. The landings at Palmerston North and Napier were said to be "uneventful" or "normal".

1.1.3 The pilot refuelled the aircraft at Napier and rested before starting the final leg back to Ardmore. The pilot said he completed a pre-flight inspection of the aircraft and an engine run-up before departing at about 2225. The 1 hour 15 minute flight to Ardmore was under instrument flight rules (IFR) but was generally in clear conditions above some cloud.

1.1.4 The pilot cancelled the IFR flight plan passing Waiuku, about 35 km southwest of Ardmore and Auckland, and continued under visual flight rules towards Ardmore.[2] The local wind was advised as being light, so the pilot elected to approach almost straight-in for runway 03. There was no other reported traffic. At about 10 km from the aerodrome the pilot activated the runway lights for the night approach.

1.1.5 The pilot selected the undercarriage down about 6 km from the runway and when established on final approach. The pilot said he also turned the landing light on at this time and checked it was working.[3] The pilot and the front seat passenger, who flew regularly, both reported seeing the 3 green down lights indicating that the undercarriage was down and locked.

1.1.6 All the occupants said the landing was smooth and on the main undercarriage. The pilot advised he gently lowered the nose of the aircraft and shortly after the nose wheel was on the ground the undercarriage began to collapse. The aircraft scraped along the runway some 100 m before veering left off the side of the runway and on to grass. As the aircraft came to a halt the pilot turned off electrical power and fuel supply and, together with the 3 passengers, exited the aircraft. Because there was a strong smell of fuel the 4 occupants assembled a short distance away before confirming that none was injured.

1.1.7 The pilot alerted air traffic services by radio telephone, who in turn advised the Police. Medical and fire services were not requested. Technical assistance was used to lift the aircraft on to a trailer and clear it from the runway area. The aircraft was secured in one of the operator's hangars until the Commission could examine it.

1.2 Damage to aircraft

1.2.1 The propellers on both engines had struck the ground and were damaged beyond repair. The engines needed to be inspected before they could be returned to service.

[2] Normally the most efficient way of approaching Ardmore as only limited instrument approach facilities were available.
[3] The landing light was positioned on the nose undercarriage oleo and would illuminate only when the undercarriage was extended.

1.2.2 The aircraft had scraped along on part of its belly and left wing, causing lower panel and antenna damage. The left undercarriage door was torn off and the wing fuel tank ruptured. The right undercarriage was partially collapsed and there was damage to the support structure. The nose undercarriage was collapsed and the doors scraped.

1.2.3 The aircraft was repairable.

1.3 Personnel information

1.3.1 The pilot was aged 34. He held a Commercial Pilot Licence (Aeroplane) and a Class 1 Medical Certificate valid until July 2003. He completed his last instrument rating and route check on 5 July 2002.

1.3.2 At the time of the accident, the pilot had amassed 2167 flying hours, including 614 hours on the Seneca type aircraft, with about 26 hours on ZK-FMW in the previous 90 days. He had flown for the operator since November 1992.

1.3.3 The pilot had a 13-hour break before commencing duty on the morning of the accident and a 7-hour break at Napier, which included 2 or 3 hours of sleep.

1.4 Aircraft information

1.4.1 ZK-FMW was a Piper PA34-200T Seneca II, serial number 8070181, manufactured in the United States in 1980. The Seneca was a low-wing, twin-engine aircraft, fitted with 2 Teledyne Continental TSIO-360 engines and retractable undercarriage. The aircraft had seating for 6 people, including the pilot.

1.4.2 The aircraft records showed ZK-FMW had been maintained in accordance with the operator's maintenance programme. The last inspection was a 100-hour check, recorded as being completed on 2 August 2002. At the time of the accident, ZK-FMW had accrued 6120 hours and had about 3 hours to run to the next scheduled inspection, a 50-hour check. The next annual review of airworthiness was due on 21 December 2002.

1.4.3 As part of its regular audit process of operators, the Civil Aviation Authority conducted an audit of the operator on 10 September 2002. The audit included a review of the operator's maintenance practices and a sample inspection of one of the aircraft from the operator's fleet. ZK-FMW was randomly selected for inspection.

1.4.4 The auditors found that the operator "… did not compromise on any maintenance requirements." ZK-FMW was considered to be "generally in excellent condition for its age" and "had the best appearance of any aircraft of that type seen by the auditor in the country."

Undercarriage system

1.4.5 The Seneca undercarriage was a standard tricycle, air-oil, strut-type undercarriage, which was hydraulically operated by an electric reversible hydraulic pump. A selector switch in the instrument panel to the left of the engine control quadrant operated the undercarriage.

1.4.6 When the undercarriage fully extended, 3 green lights directly above the selector switch illuminated to indicate that the 2 downlock hooks for the main undercarriage, and the downlock link for the nose undercarriage, had engaged. Engagement of all 3 downlocks shut off the hydraulic pump. A spring maintained pressure on the downlocks until hydraulic pressure released the spring tension during retraction. A separate red light located at the top of the instrument panel illuminated if any of the undercarriage legs were in an unsafe position, for example during extension or retraction when the locks were not engaged.

1.4.7 If a pilot did not lower the undercarriage before landing a warning horn would sound when the throttles were reduced below a specified setting. The warning horn would continue until either the engine power was increased or the undercarriage was down and locked.

1.4.8 Once on the ground, a safety switch, commonly called a squat switch and located on the left main undercarriage, prevented operation of the hydraulic pump and release of the downlocks. The undercarriage oleo leg had to extend by more than 8 inches (20 cm) before the squat switch deactivated and the hydraulic pump would operate.

1.5 Wreckage and impact information

1.5.1 Witness marks on the runway matched the reported ground track of ZK-FMW after it had landed. The marks started about 500 m from the threshold of runway 03, with 2 sets of slash marks corresponding to the dimensions of the propellers. The slash marks ran for about 25 m where further scrape and tyre marks continued and progressively veered off the left side of the runway. The marks ended about 10 m off the side of the runway where fuel had spilled on a small area of grass.

1.5.2 ZK-FMW was placed on jacks for inspection and testing. The propellers on both engines showed rotational scoring and rearwards curling of the tips, indicating the propellers were rotating with little or no power applied when striking the ground. The engines had no other obvious damage and were later removed for closer examination.

1.5.3 The nose undercarriage had partially retracted and canted off to the right. The wheel still protruded from the undercarriage well and the undercarriage doors were bent and scraped. The steering ball on top of the leg had been forced from the track assembly channel near the bottom of its travel, which was at about the fully retracted position. There was no other obvious damage to the assembly.

1.5.4 The undercarriage door for the left main undercarriage was torn off and there was some scuffing on the outboard side of the tyre. There was no other damage to the wheel assembly. The wheel was reported as being in the fully retracted position after the aircraft had come to a halt.

1.5.5 The right main undercarriage was stuck in a semi-retracted or extended position. The hydraulic actuating cylinder for raising and lowering the undercarriage was broken at the retraction fitting. The side brace and support bracket, which incorporated the downlock and supported the raising and lowering of the undercarriage, were bent and partially torn from their mountings. The downlock was still engaged but had been damaged during the accident sequence. The tyre had started to roll off the rim and there were scuffing and dirt marks on the outboard side of the tyre.

1.5.6 The undercarriage selector switch was in the down position. The aircraft hydraulic system was examined and, with the exception of the broken actuator attachment for the right main undercarriage, was undamaged. The hydraulic reservoir fluid level was full.

1.6 Tests and research

1.6.1 The steering ball was removed and the nose wheel aligned within the track assembly channel before the ball was reattached. The nose and left main undercarriages were manually lowered to full extension, where the downlocks engaged as designed. The rigging for the nose and left main undercarriages was examined and found to be within limits. The over-centre measurement for the nose undercarriage drag brace was 0.32 inches (about 8 mm). The minimum allowed was 0.30 inches (about 7.5 mm). There was a small amount of play in the rigging, consistent with the drag link passing through the over-centre position, which enabled the nose wheel to be moved forward and aft by a few degrees.

1.6.2 Manual pressure was applied to the wheels, especially to the nose wheel, in an attempt to release the downlocks. The locks remained engaged.

1.6.3 The undercarriage control and hydraulic pump electrical circuits were isolated and power was applied to the aircraft. The undercarriage position lights did not illuminate, which was as designed. Electrical power was supplied to the undercarriage control and the 3 green undercarriage lights illuminated, indicating the undercarriage was down and locked. Power was applied to the hydraulic pump, which did not run due to the undercarriage being down and locked.

1.6.4 The right main undercarriage was isolated from the hydraulic actuator and, using the undercarriage selector switch, the undercarriage was extended and retracted several times. The left main and nose undercarriage cycled normally. The downlocks and squat switches were individually tested and functioned as designed. Various combinations of downlock or squat switch isolation and undercarriage cycling were completed, and the hydraulic pump and general undercarriage system worked as designed.

1.6.5 The aircraft's electrical wiring was examined and no fault was found.

1.7 Additional information

1.7.1 A review of available incident information for Australia, United Kingdom and United States identified 4 or 5 incidents where the undercarriage had collapsed after landing without an obvious cause. However, in most cases the investigating agency concerned believed that either the undercarriage had been lowered too late, possibly after the warning horn had sounded, or undercarriage rigging was probably outside limits. Other undercarriage collapses were typically due to heavily landings and mechanical failure; the fracture of the nose wheel downlock link being common. This did not occur with the landing of ZK-FMW.

1.7.2 The manufacturer, New Piper Aircraft Incorporated, advised the Commission that a Piper PA34-220T Seneca, a type similar to ZK-FMW with up-rated engines, was involved in a landing incident in about October 2002. The aircraft was owned and operated by the manufacturer and was being flown by the manufacturer's chief test pilot at the time of the incident.

1.7.3 The manufacturer reported that after a smooth landing on the main undercarriage the nose wheel collapsed on contacting the runway. The right main undercarriage then collapsed and the left main undercarriage failed in overload. There were no injuries.

1.7.4 The investigation by the manufacturer found that the downlocks for the nose undercarriage and the main undercarriage legs had released with no evidence of any mechanical failure. The aircraft systems were inspected and no fault found. The aircraft was placed on jacks and the undercarriage lowered using the undercarriage selection switch. The 3 downlocks engaged as designed. Further inspection and testing was completed with no fault found. Finally, random lateral force was applied to the main undercarriage wheels while equally random fore and aft pressure was applied to the nose undercarriage. Only when a downlock on one of the undercarriage legs was deliberately retracted did the downlocks on the remaining legs retract when force continued to be applied to the undercarriage system. The retraction of the remaining downlocks would have in turn permitted these undercarriage legs to collapse.

1.7.5 The manufacturer was not able to identify any significant factor that contributed to the collapse of the undercarriage. The manufacturer suggested the possibility that a combination of undercarriage rigging, although still within limits, and a timely application of lateral force on the main undercarriage together with fore and aft force on the nose undercarriage could start a collapse. The nose wheel bouncing forward and backwards at touch down may have caused the drag links to flex sufficiently to break their over-centre position and unlock the nose undercarriage leg. Once this downlock was released a downlock for one of the main undercarriage legs could then have

also released. However, the manufacturer considered the chances of this occurring to be very remote.

1.7.6 In an attempt to support the manufacturer's theory, the Commission performed a similar test. Because of the level of damage to ZK-FMW, another aircraft of the same type was used. The undercarriage collapse could not be repeated.

2 Analysis

2.1 The flight was a routine charter being flown by an experienced pilot in good weather conditions. The aircraft had been maintained to a high standard as shown by the state of the aircraft and a recent audit report.

2.2 The flight proceeded normally until the final landing at Ardmore. Runway witness marks, damage to the aircraft, and reports by the pilot and passenger confirm that the sequence of undercarriage collapse was the nose wheel retracting first, followed by the left main undercarriage. The right undercarriage damage resulted from the aircraft veering to the left and placing an excessively high load on the undercarriage support structure.

2.3 Examination and measurement of the slash marks on the runway gave an estimated aircraft speed of between 60 to 70 kt at the time the nose undercarriage collapsed. The estimated landing speed was about 70 to 75 kt.

2.4 The damage to the nose undercarriage doors mainly resulted from the doors scraping along the runway. There was little compression of the doors indicating that the collapse was slow, with possibly residual pressure in the hydraulic system resisting the collapse.

2.5 The reason for the nose undercarriage collapse was not conclusively determined. The undercarriage rigging was within limits and no fault could be found with the electrical or hydraulic systems. The possibility that the undercarriage was not fully down and locked before landing was remote. Both the pilot and front seat passenger recalled seeing the 3 green lights, which confirmed the undercarriage was down and locked. The pilot reported seeing the nose wheel landing light illuminated, which also confirmed the nose wheel was down. Further, the occupants did not hear the undercarriage warning horn sound.

2.6 The possibility that the pilot momentarily selected the undercarriage switch up, thereby releasing the downlocks, was also considered unlikely. Although the undercarriage switch was near the throttles, had the pilot selected the undercarriage up, the squat switch would have prevented the hydraulic pump activating to release the downlocks. If the squat switch had failed, the right main downlock would probably have also released.

2.7 Although an electrical fault could not be identified, the possibility, albeit remote, of a fault remains. However, for an electrical fault to start the collapse a second fault or error must have occurred, for example, a combination of the pilot raising the undercarriage switch and a squat switch failure, or a simultaneous hydraulic pump activation and squat switch failure.

2.8 The collapse of an undercarriage has typically been due to a heavy landing, an electrical fault or the failure of an undercarriage component. The PA34 model of aircraft has been in service for over 30 years and, to the knowledge of the manufacturer this is one of possibly only 2 cases where the downlocks have released without an obvious cause. The collapse of the undercarriage on ZK-FMW must, therefore, be considered as an isolated incident.

2.9 In the absence of any identifiable cause, the random combination of landing forces and aircraft undercarriage rigging remains the most likely theory, however improbable it may appear. By very slowly lowering the nose wheel on to the runway, there was the potential for the nose leg to skip

forward and backward, placing a load on the undercarriage drag links. This may have been sufficient to force the links back past their over-centre position and collapse the nose undercarriage. Once the nose undercarriage lock had opened and there was significant movement of the undercarriage leg, the hydraulic pressure line could have become pressurised. The hydraulic pump may have also started to function adding to the increase in pressure. While the pressure relief valve should have vented any over pressure back into the reservoir, there may have been sufficient residual pressure to release the left main undercarriage downlock. However, the pilot of ZK-FMW did not recall feeling or hearing any shuddering of the nose undercarriage during landing.

2.10 Attempts to repeat the collapse were not successful, possibly due to a combination of the undercarriage rigging being slightly different on the test aircraft and because the forces required were far in excess of those able to be safely applied in the trial.

3 Findings

Findings are listed in order of development and not in order of priority.

3.1 The pilot was appropriately qualified, familiar with the aircraft and fit to conduct the flight.

3.2 ZK-FMW was in good condition and recorded as being correctly maintained.

3.3 The undercarriage rigging was found to be within limits.

3.4 The reason for the undercarriage collapse was not established.

3.5 A combination of landing forces, undercarriage rigging and play in the drag brace, although improbable, is a possible trigger that can cause an undercarriage to collapse, but this could not be confirmed.

Approved for publication 30 July 2003

Hon W P Jeffries
Chief Commissioner

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01-009 Bell 206B Jetranger, ZK-HWI, perceived engine power loss and heavy landing after takeoff, Mt Pisa Station, Cromwell, 11 September 2001

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Transport Accident Investigation Commission
P O Box 10-323, Wellington, New Zealand
Phone +64 4 473 3112 Fax +64 4 499 1510
E-mail: reports@taic.org.nz Website: www.taic.org.nz

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