Piper PA-34-200T Seneca II, G-ROLA

AAIB Bulletin No: 5/2004	Ref: EW/C2003/05/09	Category: 1.3
Aircraft Type and Registration:	Piper PA-34-200T Seneca II, G-ROLA	
No & Type of Engines:	2 Continental TSIO-360-EB piston engines	
Year of Manufacture:	1976	
Date & Time (UTC):	8 May 2003 at 1220 hrs	
Location:	Sherburn-in-Elmet Aerodrome, Yorkshire	
Type of Flight:	Private	
Persons on Board:	Crew - 2	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Both propellers bent, engines shock loaded, nose cone split, nose landing gear doors damaged	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	51 years	
Commander's Flying Experience:	6,355 hours (of which 750 were on type)	
	Last 90 days - 67 hours	
	Last 28 days - 14 hours	
Information Source:	Aircraft Accident Report Form submitted by the commander and further enquiries by the AAIB	

Synopsis

After completing the power and pre-takeoff checks, the handling pilot taxied the aircraft past the holding point in order to line up on Runway 29. At a reported groundspeed of approximately 5 to 7 kt the nose gear leg suddenly collapsed. The aircraft slid approximately 30 feet and came to rest with its nose and both propellers touching the ground. The aircraft was shut down and both occupants evacuated the aircraft via the main door. The probable cause of the nose gear collapse was a mis-rigged nose gear downlock spring link. One safety recommendation concerning the Seneca Maintenance Manual was made to the Federal Aviation Administration of the USA.

History of the flight

The handling pilot of the flight was undergoing training for a type conversion and renewal of his multi-engine instrument rating. He was in the left-hand seat and the commander (instructor) was in the right-hand seat. After completing the power and pre-takeoff checks, the handling pilot taxied the aircraft past the holding point in order to line up on Runway 29. At a reported groundspeed of approximately 5 to 7 kt the nose gear leg suddenly collapsed. The aircraft slid approximately 30 feet and came to rest with its nose and both propellers touching the ground. The commander reported that before shutting down the aircraft both he and the handling pilot confirmed that the gear selector was still in the down position and that the main gear was indicating '2 greens'. The aircraft was shut down and both occupants evacuated the aircraft via the main door. The commander reported that at the time of the gear collapse the handling pilot had one hand on the throttles and one hand on the control column.

Aircraft Recovery

Following the accident, engineers from a maintenance organisation arrived at the scene. They raised and supported the nose of the aircraft before attempting to pull the nose gear down. They were not able to pull it down sufficiently to lock it in the down position. An engineer boarded the aircraft and applied electrical power with the gear selector in the 'DOWN' position. At this point someone observed that the left main gear was starting to move and called 'stop'. The aircraft's electrical power was switched off and it was towed to a maintenance hangar.

Maintenance History

The aircraft had suffered a previous accident on 2 December 2001 when it over ran the runway at Top Farm (see AAIB Bulletin 2/2002). During that accident the nosewheel dug into soft ground at the end of the runway causing the nose gear to collapse. The aircraft did not fly again until temporary repairs were carried out to allow the aircraft to be flown out and in September 2002 it was flown to Sherburn for major repair work and an annual inspection.

The repair work on the nose gear included re-assembling the drag link and replacing the downlock spring link with a serviceable second-hand part. The annual inspection included functional checks of the landing gear which were found satisfactory. The repair work and annual inspection were completed in April 2003.

On 30 April 2003 the aircraft was test flown by the commander of the accident flight and one of the owners of the aircraft. During that flight they encountered some problems with the gear free-fall test. The nose gear locked down on the first attempt but it failed to lock down on two subsequent attempts whereas the left main gear did not lock down during any of the three attempts. The free-fall problem with the left main gear and nose gear was reported to the maintenance organisation and in response, they lubricated the left main gear and nose gear linkages, but no subsequent free-fall gear tests were carried out.

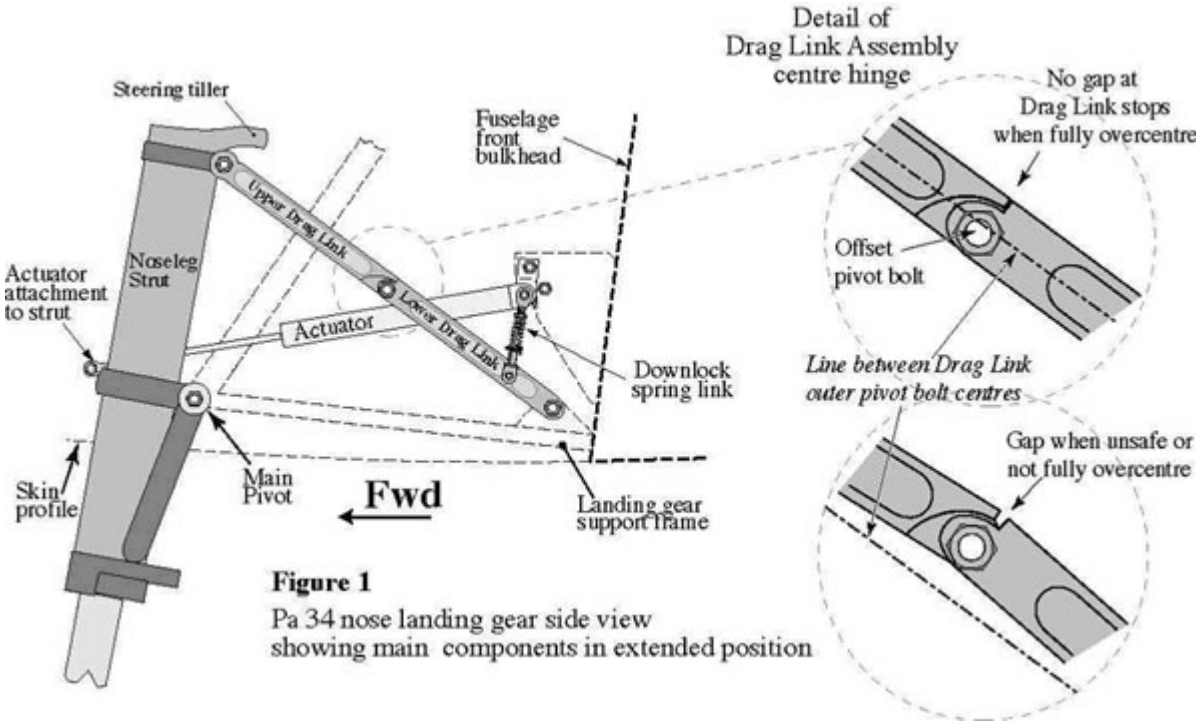
On 3 May 2003 the aircraft was on a flight to Guernsey when the gear in-transit light illuminated. The pilot cycled the gear approximately five times but on each occasion only two 'greens' came on. The right main gear position indicator would not show a 'green'. The aircraft diverted to Bournemouth and landed without incident. A maintenance organisation at Bournemouth examined the aircraft and discovered that a broken wire in the right main gear down-lock system had caused the problem and replaced the wire. However, during free-fall tests on the ground at Bournemouth the left main gear would not lock down correctly. The problem was attributed to a bent landing gear actuator. No work was done on the nose gear at Bournemouth. The aircraft was flown to Guernsey and then two days later it was flown back to Sherburn.

The maintenance organisation at Sherburn was advised of the problem with the left main landing gear. No work was done on the gear at Sherburn but a new main landing gear actuator was ordered. It was on the subsequent flight that this accident occurred.

Nose landing gear mechanism

The nose landing gear of the Seneca is of the forward retracting type which, when extended, has the wheel axle forward of the oleo pivot. When retracted, the gear is held up by hydraulic pressure in the actuator and, when extended, it is held in the down position by a geometric downlock mechanism. There are no locking hooks for either position. When the nose landing gear is extended and under load the primary brace against collapse is the drag link assembly. When the landing gear is fully extended, the drag link centre pivot should be offset below the line between its two end pivots. In this position the fixed stops of the drag link centre joint, which limit the over-centre travel of these links, should be in abutment (see Figure 1).

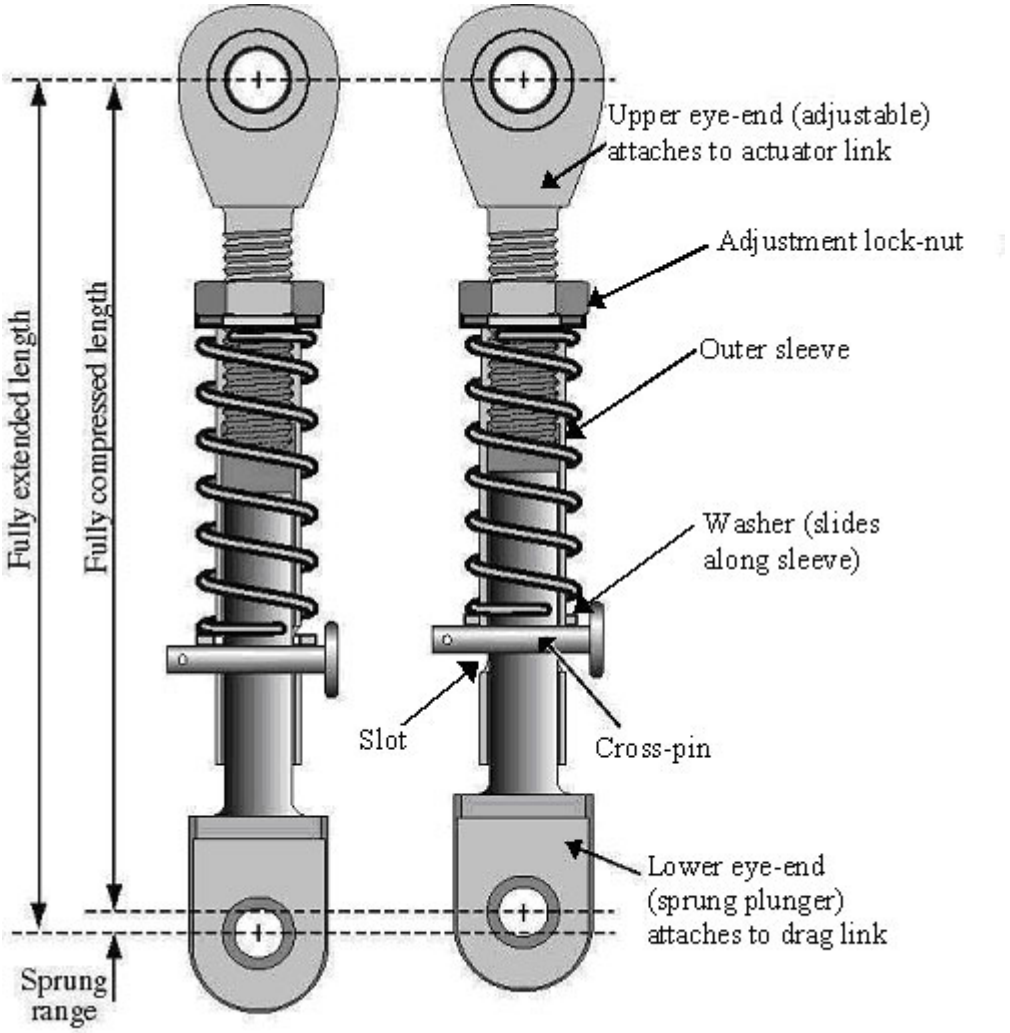
Figure 1: PA-34 nose landing gear side view showing main components in extended position



The overall geometry of the landing gear is such that aircraft weight on the nose-wheel applies a compressive load to the drag link assembly which tends to drive it more firmly into the safe over-centre condition when the gear is properly extended. Conversely, it will tend to cause the drag link to fold, and the gear to retract, if the load is applied when the drag link assembly is in an under-centre condition.

The downlock spring link helps to maintain the over-centre downlock position by applying a force on the lower drag link. It has a spring and a plunger to permit a small change in its length as it is moved in and out of lock (see Figure 2).

Figure 2: Downlock spring link in compressed and extended position



The difference between the compressed and uncompressed length should be approximately 0.08 inch. The travel of the plunger is limited by a cross-pin which abuts against a washer that presses against the spring when the link is compressed. The length of the downlock spring link is adjustable and should be rigged such that it is fully compressed when the drag link assembly is driven to the fully over-centre position. If the downlock link is adjusted too short, the drag link will not be driven to the over-centre position which could result in the nose gear collapsing.

Nose Gear Examination

Following the accident some gear extension and retraction tests were carried out under supervision of a third party on behalf of the AAIB. It was reported that when the nose gear was extended the drag link did not move to the over-centre position. In the extended position the drag link was under-centre with a 0.10 inch gap between the links at the centre pivot point. The same result was produced following further extension tests. Nevertheless, the microswitch indicated 'down and locked' despite the nose gear being under-centre. It was also reported that the slot in the downlock spring link was enlarged and that the lock-nut was loose. The drag link and downlock spring link were removed from the aircraft and sent to the AAIB for further examination.

The downlock spring link was slightly bent and the adjustment lock-nut was still loose as shown in Figure 3. The slot through which the cross-pin passed was enlarged which enabled an additional reduction in the length of the link. The enlargement of the slot had formed a lip which prevented the washer in Figure 3 from resting against the pin under the spring load (as it does in Figure 2). As a result the spring was no longer having any effect on the length of the link. The enlargement of the

slot appeared to be the result of overload crushing damage, probably sustained during the collapse. However, it is not uncommon to find enlargement of this slot due to wear. Any pre-existing wear of the slot would have been masked by the crushing damage.

Figure 3: Downlock spring link from accident aircraft

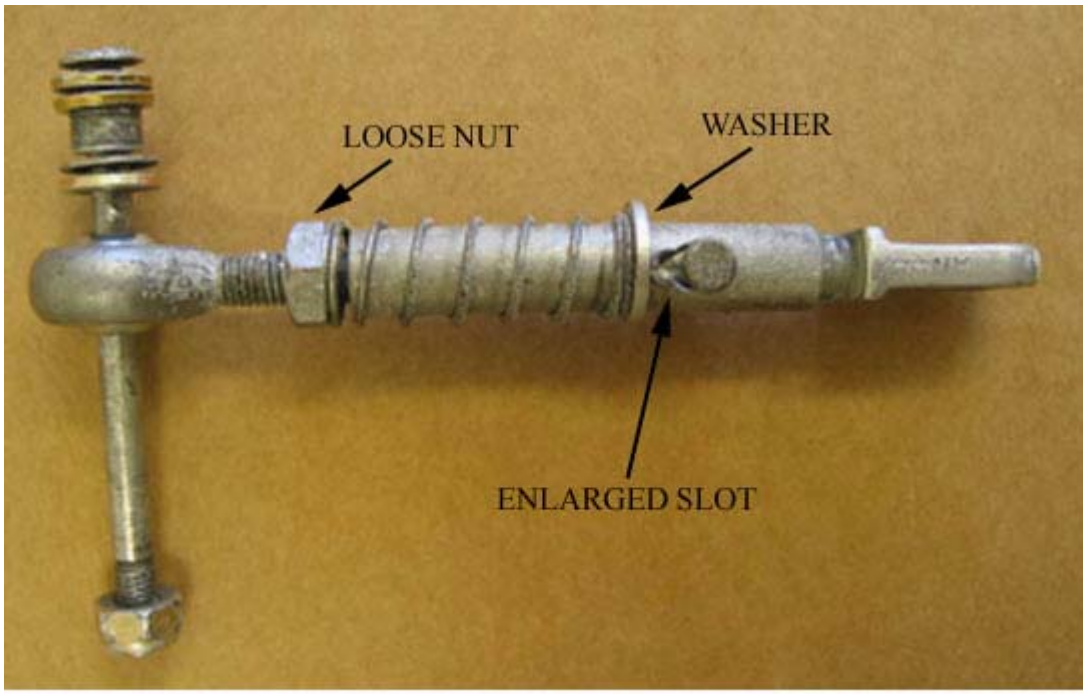


Figure 3 Downlock spring link from accident aircraft

The drag link was examined at the AAIB and it was noted that some force was required to open and close the link. The Seneca II Service Manual states that when assembling the drag link *'tighten the nuts, yet allow the links to operate freely'*. The torque on the nut attaching the upper and lower drag links was measured at approximately 50 in-lb (inch-pounds). No torque is specified in the Service Manual but any torque above 12 to 15 in-lb caused the drag link to stop opening and closing freely. A drag link from another Seneca was examined and produced the same result when torque tightened above 20 in-lb. No other anomalies were found with the drag link apart from the over-tightened nut.

Squat switch examination

The aircraft was fitted with a squat switch on the left main landing gear. The squat switch electrically isolates the landing gear hydraulics to prevent accidental gear operation when the aircraft is on the ground. The squat switch was examined on behalf of the AAIB and was found to operate correctly.

Analysis

A nose gear collapse could have been the result of an inadvertent gear up selection but both pilots reported that neither of them had a hand near the gear selector at the time of the collapse. The squat switch, which was found to operate correctly, would also have prevented an inadvertent gear retraction on the ground. In addition, the two main landing gears remained in the down and locked position during the collapse and so an inadvertent gear up selection can be dismissed as a cause.

It is possible that the nose gear collapsed due to a problem with the rigging. The aircraft had recently undergone extensive repair work and both the drag link and downlock spring link had been removed. When the drag link was reassembled it was over-tightened to the point where it would not open freely.

The extra friction would have resisted movement of the drag link into the over-centre position and would also have hindered free fall of the nose gear - a problem that was reported during the flight tests. The aircraft manufacturer was consulted about the cause of the enlarged slot on the downlock spring link. In the manufacturer's opinion an excessive amount of play in the downlock spring link could allow the drag link to move out of the over-centre position before the downlock link had moved out of its own over-centre position, resulting in an excessive loading of the downlock link and collapse of the nose gear. It appears probable, therefore, that the downlock spring link was not adjusted to the correct length. The loose nut on the threaded portion of the downlock link further indicates that adjustment was not correctly carried out.

The anomaly with the left main gear, which was seen to move when electrical power was applied to the aircraft, was not investigated in detail. However, during the inspection on behalf of the AAIB it was discovered that there was some play in the left main gear support system with the left main gear in the down and locked position. It is possible that when electrical power was applied to extend the nose gear the pressure in the main gear actuator also forced the left main gear to move within the range of play but still in the locked position. Understandably, the perception of any movement of the main gear would have alarmed an onlooker.

Conclusion

The probable cause of the nose gear collapse was a mis-rigged downlock spring link. However, the frequent occurrence of nose gear collapses on Seneca aircraft due to mis-rigging suggests that the procedure for rigging the downlock spring link is unclear.

Safety Recommendations

In the past six years the AAIB has investigated nine incidents of nose gear collapse on Piper Seneca aircraft in the U.K. Some of the nose gear collapses occurred on landing but most occurred whilst taxiing. The causes of some were inconclusive but mis-rigging of the nose gear linkages appeared a likely factor in all of them. AAIB Bulletin 12/2000 reported on two nose gear collapse accidents and made the following recommendation:

> **Safety Recommendation 2000-46** (from EW/C2000/02/06 in AAIB Bulletin 12/2000)
>
> The FAA and the CAA, in conjunction with the New Piper Aircraft Company, should investigate the causes of reported cases of Piper Seneca nose landing gear collapse. Consideration should be given to design modification which should minimise movement of the drag brace resulting from loads applied to the nose landing gear, and to ensure sufficient force is applied to the drag brace to retain it in the locked condition.

The follow up action to the recommendation stated: *'The New Piper Aircraft, Inc. are of the opinion that the nose landing gear collapsed as a result of possible improper rigging and installation. They have no plans to redesign the drag brace at this time.'* An additional recommendation was made:

> **Safety Recommendation 2000-45** (from EW/C99/06/04 in AAIB Bulletin 12/2000)
>
> The New Piper Aircraft Company should review and amplify the instructions for rigging the nose landing gear downlock mechanism contained in the Piper PA-34 Maintenance Manual.

Both safety recommendations were reiterated again in AAIB Bulletin 3/2002 following another nose gear collapse to a Seneca aircraft. The Federal Aviation Administration (FAA) accepted both recommendations. In response, the New Piper Aircraft Company issued Service Bulletin 1123 dated 7 May 2003.

Service Bulletin 1123 addressed a number of issues and included a requirement *'to inspect the nose gear down lock link assembly for binding, worn spring retention pin, and any noticeable elongation of the hole associated with the spring retention pin'.* However, it still did not provide satisfactory

instructions for rigging of the nose landing gear downlock mechanism. No additional or revised diagrams were contained in the Service Bulletin that were not already contained in the Service Manual. The Service Manual could be improved if it contained a clear description of the way the mechanism operated by both narrative and pictorial means.

The following passage from the Service Manual highlights some of the difficulty in interpretation:

> *'7. Connect the downlock link to the lower drag link and the downlock spring to the link assembly.*
>
> *8. Adjust the downlock link so it is fully compressed when the gear is down and locked. On airplanes equipped with an up stop ascertain that the three pivot points in the downlock link assembly (41) and the link assembly (53) are aligned. [NOTE: The downlock link assembly will move aft slightly with the remainder of the cylinder travel until the link contacts the stop. At this position, the downlock light switch must actuate].*
>
> *9. Install spring (44) in position on link (53) with drag link assembly fully extended (over center with upper faces in solid contact). Adjust the linkage (40) to a fully retracted position and install. [NOTE: The link (40) is fully retracted when the guide pin is bottomed out at the slot]. Free fall the nose gear a minimum of 3 times. Remove linkage (40) and readjust per Note. Shorten linkage by one-half turn clockwise and reinstall.'*

Step 9 appears to repeat steps 7 and 8. Step 7 requires installation of the downlock link and downlock spring (but there is no drawing reference number for either part). Step 8 requires adjustment of the downlock link. Step 9 then requires installation of the spring and the linkage again. The downlock link (40) is referred to alternatively as the 'linkage' and also as the 'link'. There are two springs in the whole assembly and it is not clear which is which or when each should be installed. Step 8 refers to the compression state of the downlock link while step 9 refers to it being in a retracted state - different terms appear to be used to describe the same thing. More importantly, there are no clear diagrams showing the operation of the downlock link and spring. Also, the manual does not explain what to do if the nose gear fails the free fall test. Because Service Bulletin 1123 does not address any of these issues, the AAIB makes the following recommendation:

Safety Recommendation 2004-7

> It is recommended that the Federal Aviation Administration, as the primary certificating authority for the Piper PA-34 Seneca aircraft series, should require the aircraft manufacturer to provide a clear and unambiguous description of the operation of the nose gear downlock spring link, its installation and its correct rigging by both narrative and pictorial means.