

GENERAL INFORMATION

Identification number:	2007037
Classification:	Serious incident
Date, time ¹ of occurrence:	19 April 2007, 23.17 hours
Location of occurrence:	Rotterdam Airport
Aircraft registration:	PH-HRK
Aircraft model:	Piaggio P.180 II Avanti
Type of aircraft:	Twin engine turbo propeller aircraft
Type of flight:	Charter
Phase of operation:	Landing
Damage to aircraft:	Minor
Cockpit crew:	Two
Passengers:	One
Injuries:	None
Other damage:	None
Lighting conditions:	Darkness

SUMMARY

After a flight from Stockholm Bromma Airport to Rotterdam Airport the pilot flying encountered a yaw movement to the right during the landing roll. The aircraft departed the right side of the runway and came to a standstill in the grass near the runway. The aircraft suffered minor damage and no one was injured.

FACTUAL INFORMATION

After an uneventful flight from Stockholm Bromma Airport in Sweden the flight crew prepared for a straight in instrument landing system approach for runway 24 at Rotterdam Airport. According to the captain, who performed the duties of pilot flying, the approach was flown according to company standard operating procedures.

The captain stated that at 2000 feet QNH² the gear was selected down and flaps mid were selected. While the speed was further reduced, full flaps were selected and the before landing checklist was completed. All system indications were checked and found to be within normal operating range. At 400 feet above ground level a master warning 'STALL FAIL' was generated

¹ All times in this report are local times unless otherwise specified.

² QNH is a pressure setting to refer to the barometric altimeter setting which will cause the altimeter to read altitude above mean sea level within a certain defined region.

together with an angle of attack³ fail and flight director (FD1)⁴ annunciation on the primary flight display. The crew shortly discussed the master warning and decided to continue the approach.

According to the captain the threshold crossing occurred at a normal height with a speed of 125 knots. The landing was performed manually. The main gear touched in the touchdown zone and on the centre of the runway. When the nose was lowered a right yawing moment was observed by the captain. The nose gear bounced up and when runway contact was re-established again the same right yawing moment occurred.

The captain stated he applied differential braking (left-hand brakes), selected left rudder and differential reverse power (left-hand engine only) in order to maintain directional control. The first officer declared he verified that only the left-hand engine was in reverse. The first officer declared he did not assist in applying braking force or control inputs. The aircraft movement towards the right runway edge was consistent throughout the landing rollout. The captain declared he did not engage the nose wheel steering system⁵ during the rollout because the speed was high and he did not want to agitate the situation⁶, that felt like a nose wheel problem. At some stage during the rollout the left main landing gear tire burst. The aircraft departed the right side of the runway at 355 meters from the touchdown point. The left main landing gear dug into the soil. The aircraft came to a complete rest in the grass approximately five meters from the runway edge.

The captain informed air traffic control of the runway departure and secured both engines. After inspection of outside conditions and absence of engine fire, the first officer evacuated the passenger. The aircraft suffered damage to the rim of the left-hand main landing gear and the left-hand propeller blades. No one was injured.

The ATIS⁷ indicated a wind direction varying between 340 and 310 degrees and a speed varying between 5 and 10 knots. Data from the Royal Netherlands Meteorological Institute indicates that the wind was 310/5 near the ground and 330/12 at an altitude of 500 feet.

³ The angle of attack is the angle between the chord line of the wing and the vector representing the relative motion between the aircraft and the atmosphere.

⁴ FD stands for flight director. It computes and displays the proper pitch and bank angles required in order for the aircraft to follow a selected path.

⁵ The nose wheel steering system provides directional control of the aircraft during ground operation.

⁶ Not engaging the nose wheel steering system during the roll out is conform the emergency procedures checklist.

⁷ ATIS = Automatic Terminal Information Service. ATIS is a continuous broadcast of recorded non control information in busier terminal (i.e. airport) areas. ATIS broadcasts contain essential information, such as weather information, which runways are active, available approaches, and any other information required by the pilots, such as important NOTAMs.



Illustration 1: PH-HRK after the runway excursion

INVESTIGATION AND ANALYSIS

This report is based on the on-site investigation performed by the Dutch Safety Board and the investigations performed by the airline involved and the manufacturers of the aircraft and the components of the nose landing gear. Possible underlying organizational factors of the airline and supervision by the Dutch civil aviation authority on the airline, were not investigated.

The investigation being conducted by the Dutch Safety Board started with a general check of the aircraft in a hangar at Rotterdam Airport. Aerial photographs were taken of the traces on the runway, which were caused by the aircraft. The aircraft was not equipped with a flight data recorder nor with a cockpit voice recorder. Those recorders are not required. The mass and balance form indicated that the mass and centre of gravity of the aircraft were within limits during the entire flight. The total flight time of the aircraft was 117 hours and it had made 121 landings. Because no peculiarities and limit exceedings had been found so far, the investigation focussed on the nose landing gear and its components.

The nose landing gear was removed from the aircraft and shipped to the manufacturer where it was tested in line with a production acceptance test on 6 June 2007.⁸ The steering actuator, the steering manifold, the servo valve and the command potentiometer of the nose landing gear were sent to the manufacturers of those components for separate production acceptance testing.⁹ A sample of hydraulic fluid from the nose landing gear steering actuator was taken and submitted to the materials laboratory of the landing gear manufacturer for examination of possible contaminants.

The final report of the landing gear manufacturer regarding the investigation of the nose landing gear and its parts concluded with among other things the following findings:

- *the nose landing gear satisfactorily completed steering testing.*
- *the nose landing gear steering manifold satisfactorily passed acceptance testing.*

⁸ Representatives from Messier-Dowty Ltd., Piaggio Aero Industries and the Dutch Safety Board were present.

⁹ During the testing of the steering actuator and the steering manifold an investigator of the Italian Air Safety Board, 'Agenzia nazionale per la sicurezza del volo', was present.

- *metallic and fibre particles have been found in the oil sample, however all the steering function tests have passed with satisfactory results.*

Aircraft history

The same aircraft encountered, before it had been delivered to the airline concerned, a steering problem during flight training on 21 December 2006. So far the aircraft had made 52 landings and a total flight time of approximately 31 hours. After engagement of the nose wheel steering system after landing the nose landing gear turned to the right, the pilot disconnected the steering system and the aircraft did not suffer any consequence. The same day the nose landing gear was removed and sent to the manufacturer for investigation. Another nose landing gear was installed. The steering actuator and manifold were sent to the manufacturer of those parts for investigation and repair before next installation. Six days later the nose landing gear was removed after incorrect self-centering had occurred during ground tests. Another third nose landing gear was installed. On 6 April 2007, after the airline had received the original nose landing gear from the manufacturer, it was installed again. It was not equipped with the original steering manifold and steering actuator. The cause of the then malfunction was the presence of metallic particles and other contaminants inside the manifold and inside the servo valve which is attached to the steering manifold on the nose landing gear main fitting. The debris obstructed the fluid lines causing jamming of the servo valve. The source of the debris was never proven.

The descriptions of the service bulletins and airworthiness directives with regard to the steering system that were issued can be found in appendix A.

In the period from March 2000 up to March 2008 a total of twelve runway excursions occurred with P.180 Avanti and Avanti II aircraft as a result of a malfunction or misuse of the nose wheel steering system. In three cases the cause could not be found, once a metallic chip was found jammed in the servo valve, four times pilot operation was determined as the (possible) cause and once pollution was found in the hydraulic fluid. For the remaining cases more tests have been scheduled to determine the cause.¹⁰

Investigation by the aircraft manufacturer

The aircraft manufacturer, performed further investigation on the aircraft. On 5 March 2010 the Dutch Safety Board received the investigation report regarding the runway excursion of PH-HRK from the manufacturer. This report contained among other things the following factual conclusions:

- *No evident and repeatable failure has been detected during all the investigation.*
- *All the possible failure modes were not confirmed by technical or laboratory evidences.*
- *The aircraft had the nose landing gear rotated 20 degrees to right after the event. The nose landing gear recovered the neutral position as the aircraft was lifted.*
- *The simulation of the event performed with the aircraft engineering simulator (utilizing certified aerodynamic data) following the information contained into the pilot report did not validate the trajectory of the aircraft during the runway veering off. The simulation has validated the trajectory of the aircraft during runway veering off taking into account the position of the nose landing gear at 20 degrees, hence with the nose wheel steering engagement during the landing run.*
- *The accident trajectory of the aircraft on the ground is explained by considering actions on the aircraft controls.*

¹⁰ This information is based on a survey that was sent by EASA on 14 April 2008.

- *The nose wheel rotation is compatible with a voluntary untimely engagement of the steering system in the 'take-off' mode or a hydraulic failure. In the case of a hydraulic failure the nose wheel position reaches the full travel of 50 degrees. A rotation of 20 degrees corresponds to the steering system in the 'take-off' mode.*
- *Maintenance activities were in line with relevant requirements.*
- *The steering actuator and the steering manifold had already received the cleaning through the procedure required by the EASA airworthiness directive 2007-0147-E established a few days after the incident, which directive is still active and valid.*

Based on the findings, the aircraft manufacturer tried to build a scenario which fits with all the evidences, pilot reporting, on site findings and laboratory tests.

The pilot of PH-HRK reported that the runway veering off was compatible with a steering system failure which led to an un-commanded nose landing gear rotation to the right before touchdown.

The angle of attack warning reported by the pilot could have been originated by a different status between the nose landing gear weight on wheels and the main landing gear weight on wheels. This can be explained by the nose landing gear being rotated, and therefore compressed by the self centering mechanism and giving a signal of weight on wheels, whilst the main landing gear shock absorber was fully extended and gave a signal of the main landing gear without weight on wheels.

The failure scenario could be originated by a leaking or failing shut-off valve (installed in the steering manifold), paired with an unbalanced steering servo valve. In this condition the hydraulic fluid should pass through the shut-off valve to a chamber of the steering actuator, causing hence the maximum nose landing gear rotation (of 50 degrees) till the mechanical stop. The nose landing gear shock absorber is consequently forced to be compressed by the action of the self-centering cam, activating the nose landing gear weight on wheels switch.

According to the logic of the flight director system there is no relation between the incident and the flight director (FD1) warning reported by the pilot.

Investigation by the airline

The airline investigated the occurrence and made a report.¹¹ This report ends with the following conclusions:

- *Based on the statement of the captain and the traces on the runway, that indicate that the angle of the nose gear did not match the travelling direction of the airplane, it is assumed that the steering system was off during the ground roll. Question at hand is why the nose gear was not free to castor with the system off.*
- *A visual inspection of the nose gear did not unveil external blockings that could explain a possible jam. Secondly, the question arises to the cause of the nose gear to be blocked in the 20 degrees offset position.*
- *The issued airworthiness directive indicates that 'if not corrected, a contaminated fluid could cause malfunction and a possible jamming of the steering system'. Since the, per airworthiness directive prescribed, actions were performed on the applicable unit, the corrective action method chosen by the aircraft manufacturer per service bulletin 80-0236 might not prevent the steering system to malfunction.*
- *Related to the actions of the crew during the event, it can be said that the pilot flying acted in accordance with both the aircraft manufacturer and the airline standard operating procedures*

¹¹ Occurrence investigation, SOX029. Date, August 2010.

and emergency checklist memory items. It is the opinion of the investigator that the prompt reaction of the pilot flying prevented the airplane to depart the runway at a higher speed. The performed evacuation of the airplane was executed professional with great care for the passenger.

- *At this moment of the investigation, the most likely cause for this incident is related to a failure of the steering system.*

The conclusions of the investigations by the aircraft manufacturer and the airline differ in particular in the matter of activation of the steering system during the landing roll. Because the aircraft was not equipped with a flight data recorder this could not be verified.

CONCLUSION

The cause of the problem that during the roll out after the landing no directional control could be maintained, which finally resulted in a runway excursion, could not be determined univocally.

Note: This report has been published in English and Dutch language. If there are differences in interpretation the Dutch text prevails.

APPENDIX A: SERVICE BULLETINS AND AIRWORTHINESS DIRECTIVES

On 22 March 2007 the aircraft manufacturer issued a mandatory service bulletin¹² (SB) requiring an inspection/replacement of steering system components. The reason for the SB as stated, was that hydraulic oil contamination of the steering system has been detected in some aircraft on the production line. Oil contamination can cause malfunction of the steering system. The SB states that the oil sample of the nose landing gear steering actuator has to be inspected. Metallic particles in the oil sample which are greater than 100 microns are cause for rejection.

On 30 March 2007 an emergency airworthiness directive¹³ (AD) was issued by the European Aviation Safety Agency (EASA) because several aircraft, at the factory, presented some debris in the hydraulic fluid of the steering system. If not corrected, a contaminated fluid could cause malfunction and a possible jamming of the steering system. Investigations revealed that some components of the steering system can be responsible for the fluid contamination because of an initial pollution on their manufacturing.

This emergency AD aims to identify the possible defective components either in service or on the shelf, introduce if necessary, limitations per a temporary change of the Airplane Flight Manual, test the possible polluted components by means of a hydraulic analysis and to replace the identified defective components.

A revision¹⁴ of the original SB (dated 22 March 2007) was issued on 15 May 2007 to modify the operational procedure and the list of suspected serial numbers. Due to those changes the revision was applicable also to those airplanes that had shown compliance to the original issue of the SB.

On 15 May 2007 a SB¹⁵ was issued by the landing gear manufacturer to make sure that steering actuators and steering manifolds with possible oil contamination are replaced and sent for inspection and re-work where necessary.

EASA issued a new emergency AD¹⁶ on 22 May 2007. The above-mentioned AD (dated 30 March 2007), that was replaced by this new emergency AD, was issued to address an unsafe condition. This new AD expanded applicability of the previous AD to all P.180 'Avanti' series aircraft and the list of defective components as listed in revision 1 of SB, dated 15 May 2007. This new AD also required temporary changes to the respective Airplane Flight Manual and Aircraft Maintenance Manual and introduces procedures to recondition defective units.

On 18 June 2008 the aircraft manufacturer issued a mandatory service bulletin¹⁷ which describes a procedure to verify the leakage proofness of the steering manifold when the system is turned off and hydraulic power is available.

¹² SB (Mandatory) N.: 80-0236 rev. 0. Title: P180 Avanti & Avanti II – Steering System Inspection – Temporary Limitation.

¹³ EAD No: 2007-0088-E. Steering system components & Hydraulic fluid Inspection / Replacement.

¹⁴ SB (Mandatory) N.: 80-0236 rev. 1. Title: P180 Avanti & Avanti II – Steering System Inspection – Temporary Limitation.

¹⁵ SB No. P180-32-24: Landing gear – nose landing gear – steering actuator and steering manifold – inspection of units with possible oil contamination.

¹⁶ EAD No: 2007-0147-E. Steering system components & Hydraulic fluid Inspection / Rework.

¹⁷ SB (Mandatory) 80-0249, Steering manifold leakage test.

APPENDIX B: COMMENTS PARTIES INVOLVED

A draft report was submitted for inspection of factual inaccuracies to the parties directly involved in accordance with the Dutch Safety Board Act. In so far as non-textual, technical aspects and factual inaccuracies are concerned, the Board has incorporated the comments received into the final report. The remarks are mentioned in this appendix with reasons why the Board has or has not amended the report on these points. The paragraph and chapter numbers refer to the numbering in the draft report and do not always correspond to the numbering in the final report.

The draft version of this report has been submitted to the following parties:

- Airline
- Aircraft manufacturer
- Captain
- European Aviation Safety Agency (EASA)
- First officer
- Italian Air Safety Board (ANSV)
- Landing gear manufacturer

The Board received no reaction and/or remarks from the captain, the first officer, the ANSV and the landing gear manufacturer.

Airline

1. Remark:

Page 1 'summary'.

Sentence 'the captain encountered during the landing roll' is not correct qua structure. My suggestion is 'the captain encountered during the landing roll a not commanded yaw movement to the right as a result of what the aircraft could not be held on the runway'. This prevents as well that the captain should be the problem (this is what the present sentence suggests).

Board response:

Text has been amended.

2. Remark:

Page 2, third paragraph.

Piaggio has no 'thrust reverse' but a propeller with beta range/reverse power

Board response:

Text has been amended.

3. Remark:

Page 2, third paragraph.

Add to first sentence: '(left-hand engine only) and full deflection of the rudder'.

Board response:

Text has been amended. The captain declared he tried to maintain control by using among other things 'left rudder'.

4. Remark:

Page 2, third paragraph.

The sentence 'The captain didwheel problem' is correct but not complete. Not selecting the steering system is conform the abnormal/emergency checklist of both the manufacturer and the

airline. Else it seems as if the captain on his own initiative with a base of an idea deviated from the normal procedure. Add this sentence.

Board response:

A footnote has been added.

5. Remark:

Page 2, fourth paragraph, third sentence:

Damage to the rim was not caused because the main landing gear dug into the soil, but just because of jamming of the brake of the left hand main landing gear.

Board response:

Text has been amended.

6. Remark:

Page 3, first paragraph:

The report is based as well on the investigation performed by the airline. Our own report is not mentioned anywhere, while a big part of the sentences has been reproduced word for word.

Board response:

Text has been amended.

7. Remark:

Page 3, second paragraph:

Sentence 'Underlying organizational factors not investigated' suggests that organizational factors were possibly present.

Adapt: 'Possible underlying organizational factors ...'.

Board response:

Text has been amended.

8. Remark:

Page 3, fifth paragraph:

When mentioning the findings, the in the preceding paragraph named servo valve, steering actuator and command potentiometer are not named. Are there no findings related to them?

Board response:

Text has not been amended. Only the most relevant findings are mentioned.

9. Remark:

Page 3, sixth paragraph:

The first sentence suggests that this incident happened within the same airline. This incident however occurred with a test pilot of Piaggio (supplier) before the aircraft was delivered to the airline.

Board response:

Text has been amended.

10. Remark:

Page 4, third paragraph:

At the remark that in a period of 8 years 12 aircraft (related to the number of aircraft produced) departed the runway, more is expected than a simple observation. What were the causes of those incidents that were investigated as well by different authorities?

Board response:

The causes of the incidents are mentioned in broad outlines.

11. Remark:

Page 4 'Investigation by Piaggio Aero Industries'

The investigation by the airline is not mentioned at all. I think it's a gross shortcoming of the report of the Board. In particular the conclusions of our own report (page 15, sub 6 and page 16) should be added. For the sake of completeness I added our own report (Investigation PH-HRK).

Board response:

The conclusions from the report have been taken over.

Aircraft manufacturer

1. Remark:

Page 2, third paragraph:

Insert 'declared he' in: The first officer [...] verified...

Board response:

Text has been amended.

2. Remark:

Page 2, third paragraph:

Insert 'declared he' in: The first officer [...] did not assist...

Board response:

Text has been amended.

3. Remark:

Page 2, third paragraph:

Insert 'declared he' in: The captain [...] did not engage...

Board response:

Text has been amended.

4. Remark:

Page 2, third paragraph:

Add 'due to tire blockage' to: ... the left main landing gear tire burst [...].

Board response:

Text has not been amended in 'factual information', because this has not been investigated and determined by the Dutch Safety Board.

5. Remark:

Page 3, third paragraph: The weather did not play a factor in the cause of the accident.

This sentence should be eliminated because the touch down position of the nose wheel is compatible with the rudder needed for cross wind landing.

Board response:

Text has been amended.

6. Remark:

Page 3, fifth paragraph.

First bullet: Please delete it because it is not included into the aircraft manufacturer report.

Board response:

This finding has been removed, because it is based on a statement of the captain.

7. Remark:

Page 3, fifth paragraph.

Add bullet: The nose landing gear after the incident was at 20°. The NLG wheel has no mechanical stop at 20°. A pilot NLG engagement in take-off mode allows the wheel to rotate at 20°.

Board response:

The text has not been added, because it is not mentioned in the final conclusions in the report of the manufacturer of the landing gear.

8. Remark:

Page 4, third paragraph.

In the period from March 2000 up to March 2008 a total of twelve runway excursions occurred with P.180 Avanti and Avanti II aircraft.

Add: Four out of them have been clearly recognized as pilot control mishap.

Board response:

Text has been amended. This is determined by several investigation authorities.

9. Remark:

Page 4, fifth paragraph.

Add to third bullet: The NLG recovered the neutral position as the aircraft was lifted.

Board response:

Text has been amended.

10. Remark:

Page 4, fifth paragraph.

Add to fourth bullet: The accident trajectory on ground of the aircraft is explained considering actions on aircraft controls.

Board response:

Text has been amended.

11. Remark:

Page 4, fifth paragraph.

Add to fourth bullet: The NW rotation is compatible with a voluntary untimely engagement of the steering in take-off mode or a hydraulic failure. In the case of an hydraulic failure the NW position reaches full travel to 50°. The NW after the incident was at 20°.

Board response:

Text has been amended.

12. Remark:

Page 5, second paragraph.

Add 'to full mechanical stop at 50°' to: ... causing hence the nose landing gear rotation [...].

Board response:

Text has been amended.

13. Remark:

Page 5, second paragraph.

Add 'In the event of hydraulic failure the steering actuator would rotate the NLG to 50°' at the end.

Board response:

Not added, because it is already mentioned in the report.

14. Remark:

Page 5. Add 'The gusting crosswind condition has most likely required rudder command adjustments' after second paragraph.

Board response:

Text has not been amended, because this had not been stated by the captain.

European Aviation Safety Agency (EASA)

1. Remark:

The PAI report stresses the incompatibility between the position of the NLG (20° right) and a hydraulic failure (which should cause a 50° steering of the NLG with a switched off system), while that angle (20°) is compatible with a switched on system in take-off position; this seems not clearly reported in your report (p.4);

Board response:

Text has been amended.

2. Remark:

Consequently, due to the lack of other evidences that the system was switched off, it is important that the sentence "The captain did not engage ..." (p.3, 3rd par.) and all the others in that paragraph are clearly reported as declarations (e.g.: The captain also stated that he did not engage ...);

Board response:

Text has been amended.

3. Remark:

The Messier-Dowty report does not include the finding "the nose wheel steering system was switched off at the time of the incident." as reported in the list at p.3, but it attributes the sentence to the pilot's comments.

Board response:

Text has been amended.