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Aircraft Accident Investigation Bureau AAIB

Final Report No. 2103 by the Aircraft Accident Investigation Bureau

concerning the accident involving

the Diamond DA 42 aircraft, registration HB-LUO

on 19 April 2010

Zurich Airport

Aéropôle 1, Route de Morens, CH-1530 Payerne

Ursache

Der Unfall ist darauf zurückzuführen, dass das Flugzeug eine Landung mit eingezogenem Fahrwerk durchführen musste, weil sich das linke Hauptfahrwerk nicht ausfahren liess.

Kausal für diese Fahrwerkstörung war der Umstand, dass das linke Hauptfahrwerk gegenüber dem Fahrwerkschacht nicht zentriert war, so dass sich der Reifen im Fahrwerkschacht verklemmte.

Die folgenden Punkte haben zum Unfall beigetragen:

- Das durch den Flugzeughersteller vorgegebene Verfahren zur Überprüfung der Freiheit zwischen Rad und Fahrwerkschacht war mangelhaft.
- Der Umstand, dass auf dem Rad des linken Fahrwerks ein Reifen montiert wurde, der bezüglich Aussendurchmesser und Querschnitt geringfügig von demjenigen abwich, welcher vom Flugzeughersteller vorgesehen war.

General information on this report

This report contains the conclusions of the Aircraft Accident Investigation Bureau (AAIB) on the circumstances and causes of the accident which is the subject of the investigation.

In accordance with Art 3.1 of the 9th edition, applicable from 1 November 2001, of Annex 13 to the Convention on International Civil Aviation of 7 December 1944 and Article 24 of the Federal Air Navigation Act, the sole purpose of the investigation of an aircraft accident or serious incident is to prevent accidents or serious incidents. The legal assessment of accident/incident causes and circumstances is expressly no concern of the accident investigation. It is therefore not the purpose of this investigation to determine blame or clarify questions of liability

If this report is used for purposes other than accident prevention, due consideration shall be given to this circumstance.

The definitive version of this report is the original in the German language.

All times in this report, unless otherwise indicated, follow the coordinated universal time (UTC) format. At the time of the accident, Central European Summer Time (CEST) applied as local time (LT) in Switzerland. The relation between LT, CET and UTC is:
LT = CEST = UTC + 2 hours.

Final Report

Aircraft type	Diamond DA 42		Registration HB-LUO	
Operator	Swiss Aviation Training Ltd., Postfach, CH-8058 Zurich			
Owner	Swiss Aviation Training Ltd., Postfach, CH-8058 Zurich			
Pilot A (flying instructor)	Swiss citizen, born 1954			
Licence	ATPL(A), first issued by the Federal Office of Civil Aviation (FOCA) on 26 September 1994			
Essential ratings	A330/340 PIC, MEP (land), Pilatus PC7, SEP (land) FI(A), TRI(A) restricted, MPLI(A), FII(A), IRI(A)			
Medical fitness certificate	Class 1&2, without restrictions Valid from 19 May 2009 till 6 June 2010			
Flying hours	**total**	18 814:14 hours	**during the last 90 days**	195:47 hours
	on the accident type	344:29 hours	**during the last 90 days**	28:02 hours
Pilot B (flying instructor under advanced training)	Swiss citizen, born 1976			
Licence	ATPL(A), first issued by the Federal Office of Civil Aviation FOCA on 11 December 2003			
Essential ratings:	A330/340 COPI, MEP (land), SEP (land), FI(A)			
Medical fitness certificate	Class 1&2, without restrictions Valid from 9 November 2009 till 18 November 2010 and 18 November 2014 respectively			
Flying hours	**total**	5907:45 hours	**during the last 90 days**	105:45 hours
	on the accident type	22:08 hours	**during the last 90 days**	12:34 hours
Location	Zurich Airport			
Coordinates	---		**Elevation**	---
Date and time	19 April 2010, 17:01 UTC			
Type of operation	Training			
Flight phase	Landing			
Type of accident	Gear up landing			

Injuries to persons

Injuries	Crew	Passengers	Total number of occupants	Others
Fatal	0	0	0	0
Serious	0	0	0	0
Minor	0	0	0	0
None	2	1	3	Not applicable
Total	2	1	3	0

Damage to aircraft	Slightly damaged: entrance steps, engine cowling, exhaust pipes and propeller tips
Other damage	None

1 Factual information

1.1 Pre-history and history of the flight

1.1.1 General

The recordings of radio communication, radar data and the statements of the crew were used for the description of the history of the flight. The aircraft was equipped with neither a CVR (cockpit voice recorder) nor an FDR (flight data recorder).

On the day of the accident, the airspace over the whole of Switzerland, and in most European countries, was closed to commercial flights under instrument flight rules (IFR) and to the operation of jet aircraft. The reason for this was the eruption of the Eyjafjalljökull volcano in Iceland, which was spreading volcanic ash of unknown concentration over the whole of Europe. Flights under visual flight rules were, however, permitted.

The flight took place as part of a flying instructors' course to train instrument flying instructors on multi-engine aircraft. A flying instructor was sitting in the left-hand seat and a flying instructor under advanced training was sitting in the right-hand seat. The latter was a flying instructor trained on single-engine aircraft (single engine piston – SEP) and had already acquired the rating to fly the DA 42 aircraft type (multi engine piston – MEP) in January 2010.

The approach and landing at Zurich Airport were carried out by the flying instructor in the left-hand seat.

The fight took place under visual flight rules (VFR).

1.1.2 Pre-history

In the period from 12 to 23 April 2010, the "Swiss Aviation Training" flying school held a course for flying instructors in Grenchen. This course included advanced training on the type DA 42. The main aim was to train the budding flying instructors in controlling the aircraft from the right-hand seat.

On the morning of 19 April 2010 the aircraft was refuelled in Grenchen with 103 litres of fuel. The main tanks were then filled; there were 49 US gal (185.5 l) of useable fuel on board. Before the flight involved in the accident, aircraft HB-LUO took off at 11:51 UTC from Grenchen on a flight to Bern. The flying instructor involved in the accident (pilot A) sat in the left-hand pilot's seat and another participant on the flying instructors' course sat in the right-hand seat. The flying instructor under advanced training who was on the flight involved in the accident (pilot B) was sitting in the rear seat as a passenger. Four touch and goes[1] were performed in Bern and the crew then flew to Ecuvillens. During this flight, the crew flew at a maximum altitude of 5500 to 6000 ft QNH. After two go-arounds in Ecuvillens, the crew flew on to Lausanne, where they landed at 13:45 UTC.

[1] Touch-and-go – landing and subsequent immediate take-off

1.1.3 History of the flight

At 14:23 UTC the DA 42 aircraft, registration HB-LUO, took off from Lausanne on a training flight under visual flight rules. On board were pilot A in the left-hand seat in his role as trainee pilot and pilot B in the right-hand seat in his role as flying instructor. The second participant on the flying instructors' course was sitting as a passenger in the rear seat.

After an aerodrome circuit in Lausanne, followed by a low go-around, the crew flew into the Villeneuve-Aigle region to perform various flying manoeuvres.

One of these exercises required a slow descent at an airspeed of 80 kt and a rate of descent of 500 ft per minute. In order to be able to do this, the landing gear had to be extended. The aircraft was at an altitude of 6500 ft QNH.

After extending the landing gear, the crew noticed that only the lights for the right main landing gear and the nosewheel were showing green. The left main landing gear indicated no green light and the red unsafe light lit up.

The flying exercises were aborted and fault-finding was initiated.

A second aircraft from the flying school, a DA 42, callsign HB-LUK, which was also in the air was called on the radio to check the landing gear visually from outside. The crew of HB-LUK confirmed that the right main landing gear and the nosewheel were extended and that the left main landing gear was retracted. This corresponded to the display inside the cockpit of HB-LUO. It was also possible to ascertain from outside that on extension and retraction, the left main landing gear only moved slightly from the retracted position.

With the help of the crew of HB-LUK, telephone contact was also established with a specialist in the type DA 42 from the flight maintenance of the Motorflug-gruppe Zürich (MFGZ). In addition to consultation of the corresponding checklists and the information in the aircraft manufacturer's airplane flight manual (AFM), various flying manoeuvres with positive and negative acceleration were also performed to try to get the landing gear to extend. All the attempts, which also included operation of the emergency gear extension lever, were unsuccessful.

A further attempt was made by switching off the electrical power to the aircraft. Overhead the airport Langenthal, the crew switched off both alternators and the electrical master switch. The crew got the impression that the gear extended immediately after switching off the electrical power. Since there was no indication in the powerless cockpit, the crew of the HB-LUO let the condition be verified from outside by the crew of the HB-LUK. The known condition of the asymmetrically extended gear was shown.

The second participant on the flying instructors' course, in the rear seat, was also involved in the fault-finding effort.

Since all attempts to extend the landing gear failed, the crew decided to make a gear-up landing at Zurich Kloten airport.

For the gear-up landing the crew consulted the corresponding emergency procedures in the checklists and the aircraft manufacturer's airplane flight manual (AFM). The crew then decided, as mentioned in the AFM, to shut down both engines and to shut off the fuel supply shortly before the landing in order to reduce the risk of a fire on landing. However they refrained from switching off the electrical master switch because they wanted to avoid an incomplete extension of the landing gear again.

The crew of the second DA 42, which was in the air, HB-LUK, called Zurich Airport aerodrome control at 16:47:24 UTC. They informed them that they were five miles south of the airport at 3500 ft QNH and requested a landing. Approximately half a minute later they informed aerodrome control that in about five minutes a second DA 42 with landing gear problems would contact them in order to make a gear-up landing in Zurich.

At 16:53:56 UTC the crew of HB-LUO reported to Zurich aerodrome control as follows: *"Zuri tower guete Tag* [good day] *Hotel Bravo Lima Uniform Oskar, approaching Sierra at three thousand five hundred feet, we have er gear problem and for that reason I declare PAN-PAN, PAN-PAN, PAN-PAN for a gear up landing in Zurich and we request a very long runway."*

The air traffic controller (ATCO) then cleared the crew for a direct approach on runway 34. At 16:55:09 UTC the crew also requested the fire brigade from aerodrome control, which was confirmed immediately by the ATCO concerned.

In the meantime, the second DA 42, HB-LUK, made a landing on runway 28 at Zurich-Kloten.

After a brief discussion concerning the touchdown point on landing, the crew of HB-LUO confirmed to the ATCO that they wanted to touch down at the start of runway 34 in order to come to a standstill before the intersection with runway 28.

At 16:57:31 UTC the crew reported to the ATCO as follows: *"Roger, and er short before touchdown we shut down two, er both engines and er after landing we will not have er communication er with you."* The ATCO confirmed this message and shortly afterwards gave the landing clearance with the additional info that the fire brigade were ready.

Shortly before touchdown the crew shut down both engines, switched off the fuel supply and put the aircraft down on the centreline at a speed of approximately 60 kt just before the runway marking "34". The aircraft came to a standstill after 220 metres (Annex 5).

The two pilots and the third pilot flying with them as a passenger were able to leave the aircraft uninjured. The aircraft was damaged.

1.2 Meteorological information

1.2.1 General

The information in chapters 1.2.2 to 1.2.4 was provided by MeteoSwiss.

1.2.2 General meteorological situation

[translated from German] *A high-pressure system extended from Spain over the Alps as far as the North Sea. Drier air masses were increasingly moving towards the Alps on gentle north-westerly high-altitude winds. As a result, the ceiling of the unstable base layer dropped to approximately 10 000 ft AMSL.*

1.2.3 Weather at the time and location of the accident

On the basis of the listed information, it is possible to conclude that the weather conditions at the time and in the area of the accident were as follows:

Cloud	*1/8 at around 8400 ft AMSL*
Weather	*-*
Visibility	*Around 20 km*
Wind	*West-north-west at 4 kt*
Temperature/dewpoint	*18 °C / 02 °C*
Atmospheric pressure	*QNH LSZH 1013 hPa, QNH LSGG 1013 hPa, QNH LSZA 1011 hPa*
Position of the sun	*Azimuth 273°, elevation 12°*
Hazards	*None detectable*

1.2.4 Aerodrome meteorological reports

At the time of the accident, the following meteorological terminal aerodrome reports (METAR) were valid for Zurich Airport:

LSZH 191650Z 28004KT 250V320 9999 FEW070 19/02 Q1013 NOSIG=

In clear text, this means: On 19 April 2010, shortly before the 16:50 UTC issue time of the meteorological terminal aerodrome report, the following weather conditions were observed:

Wind	From 280° at 4 kt, wind direction alternating between 250° and 320°
Meteorological visibility	At least 10 km
Cloud	1-2 eighths at 7000 ft AAL[2]
Temperature/dewpoint	19 °C / 02 °C
Atmospheric pressure	1013 hPa, pressure reduced to sea level, calculated using the values of the ICAO standard atmosphere
Short-term forecast	No significant change expected in the next two hours

The following long-term terminal area forecast (TAF) was also active for Zurich Airport:

LSZH 191125Z 1912/2018 25005KT 9999 FEW035 TX18/1914Z TN06/2006Z TX16/2014Z BECMG 2006/2009 BKN060 TEMPO 2013/2018 SHRA

In clear text, this means: On 19 April 2010, at 11:25 UTC, the following long-term weather conditions were forecast for Zurich airport between 12:00 UTC on 19 April and 18:00 UTC on 20 April 2010:

Wind	from 250° degrees at 5 kt
Meteorological visibility	At least 10 km
Cloud	1-2 eighths at 3500 ft AAL
Forecast temperatures	On 19 April at 14:00 UTC a maximum temperature of 18°C; on 20 April at 06:00 UTC a minimum temperature of 6°C and at 14:00 UTC a maximum temperature of 16°C

[2] ft AAL: feet above aerodrome level

Weather change	On 20 April between 06:00 and 09:00 UTC a regular or irregular transition to 5-7 eighths cloud will occur. On 20 April between 13:00 UTC and 18:00 UTC occasional rain showers can be expected, lasting in individual cases less than one hour and in total less than two and a half hours.

The following information for arrival and departure (automatic terminal information service – ATIS) was broadcast from Zurich Airport at the time of accident:

"Zurich arrival information alfa, landing runway 14, ILS approach, met report Zurich 1650Zulu, wind varying between 250 and 320 degrees, three knots, visibility ten kilometres or more, touchdown zone ten kilometres or more, clouds few 7000 ft, temperature 19 degrees, dew point 2 degrees, QNH 1013, nosig."

1.3 Aircraft information

1.3.1 General

Registration	HB-LUO
Aircraft type	Diamond DA 42
Characteristics	Twin-engine propeller aircraft of composite construction, constructed as a low-wing aeroplane with four seats, equipped with retractable landing gear in nosewheel configuration.
Manufacturer	Diamond Aircraft Industries GmbH, Wiener Neustadt, Austria
Year of manufacture	2008
Serial number	42.334
Owner	Swiss Aviation Training Ltd., Postfach, CH-8058 Zurich, Switzerland
Operator	Swiss Aviation Training Ltd., Postfach, CH-8058 Zurich, Switzerland
Engines	Thielert Aircraft Engines Type TAE 125-02-99, year of manufacture 2008 RH serial number 02-02-02223 LH serial number 02-02-02225
Propeller	MT Propeller Type MTV-6-A-C-F, year of manufacture 2008 RH serial number 080081 LH serial number 080080
Operating hours	932.7 hours
Number of landings	2147
Max. permitted masses	Max. permitted take-off mass: 1785 kg Max. permitted landing mass: 1700 kg

Mass and centre of gravity	Both the mass and centre of gravity were within the permitted limits according to the airplane flight manual (AFM).
Maintenance	The last scheduled maintenance took place on 25 February 2010 at 906.7 hours of operation (100-hour check). For further details cf. section 1.5.
Permitted fuel grade	JET A1 kerosene
Fuel	After the accident there were still 6 US gal (22.7 l) of fuel in the left tank and 4 US gal (15.1 l) in the right tank.
Registration certificate	Issued by the FOCA on 26 June 2008, valid till removal from the aircraft register.
Airworthiness certificate	Issued by the FOCA on 26 June 2008, valid till revoked.
Subsequent airworthiness certificate	Date of issue: 19 June 2009 Date of expiry of validity: 26 June 2010
Certification	Private
Category	VFR by day / VFR by night IFR Category I / B-RNAV (RNP 5)

1.3.2 Landing gear

1.3.2.1 General

The aircraft type DA 42 has retractable landing gear, in nosewheel configuration, which is operated hydraulically. An electrically operated hydraulic pump provides the necessary hydraulic pressure.

The landing gear lever is on the instrument panel and has to be pulled out so that it can be set to the corresponding "up" or "down" position.

When the landing gear is retracted, the main landing gear wheels are retracted into corresponding wheel wells in the wing, and the nosewheel is housed in the nose of the aircraft. Hydraulic pressure maintains the landing gear in the retracted position.

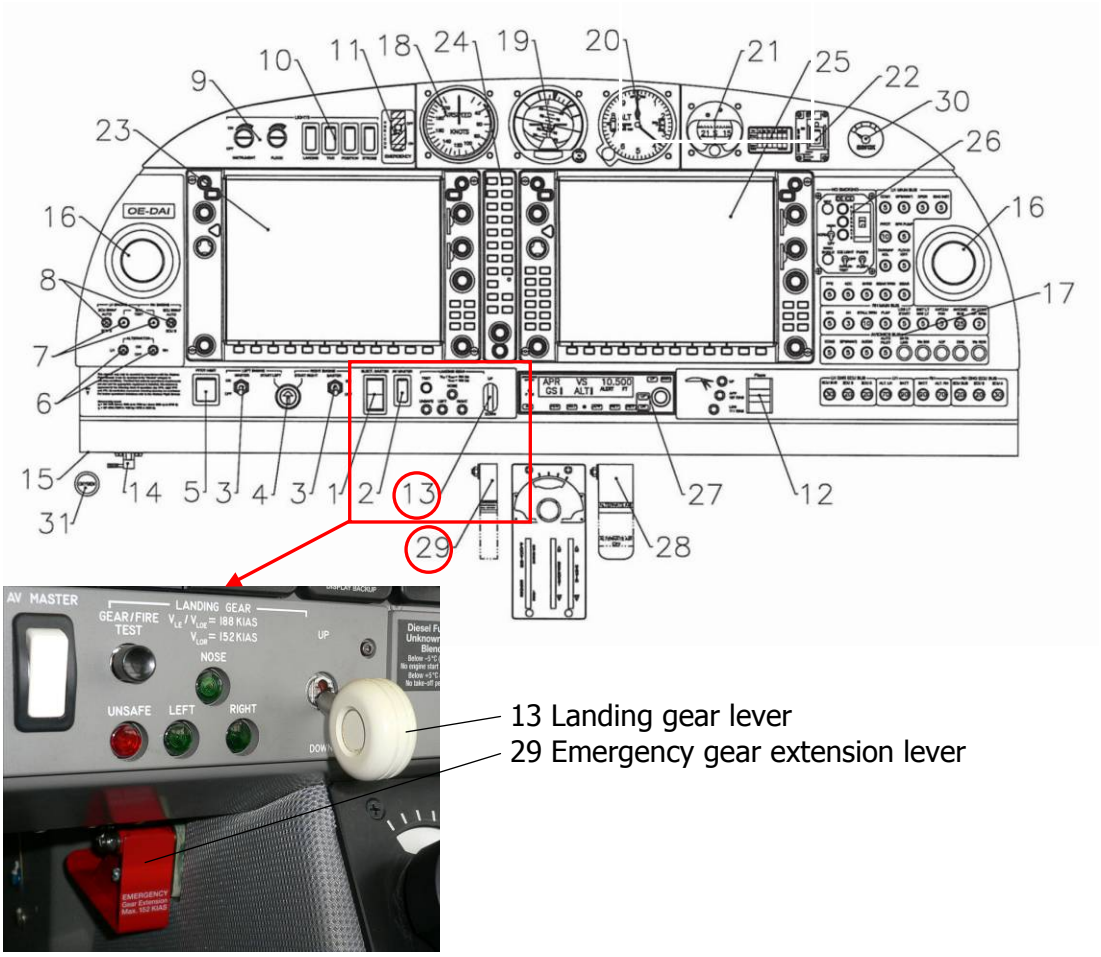
Springs assist the hydraulic system during extension and secure the landing gear in the extended position.

Three green lights (left, nose and right) directly adjacent to the landing gear lever indicate when the landing gear is extended and secure. If the gear is neither fully extended nor retracted, the red (unsafe) warning light illuminates; it is located directly adjacent to the green lights (cf. chapter 1.3.2.3).

1.3.2.2 Emergency procedure

The landing gear is designed to enable manual extension in the event of a fault in the hydraulic system. To do this, the emergency gear extension lever must be pulled. This is located below the instrument panel, on the left side of the centre console. Operating the emergency gear extension lever causes a drop in hydraulic pressure, so that the landing gear extends under the influence of gravity and is locked by the springs.

1.3.2.3 Cockpit indications and controls



13 Landing gear lever
29 Emergency gear extension lever

1.3.2.4 Tyres

According to the manufacturer's illustrated parts catalogue, the main landing gear must be fitted with one tyre respectively, Diamond part number D60-9032-17-02, designation 15x6.0-6 (6 ply rating) [type, according to Goodyear part number: 156E61-3]. According to the Goodyear tyre manufacturer's aircraft tyre data book, section 4 data section-tyres, the outer diameter of this so called Flight Special II tyre, at the nominal pressure of 68 psi (4.7 bar), is min. 14.55 in (36.96 cm) and max. 15.2 in (38.6 cm).

According to the aircraft manufacturer's AFM, in the section on handling, care, maintenance, the correct pressure is 4.5 bar (65 psi).

The nosewheel is fitted with a tyre part No. D60-9032-23-02, designation: Goodyear 505C01-2; 5.00-5; 10 ply rating. According to the Goodyear tyre manufacturer's aircraft tyre data book, section 4 data section-tyres, the nominal pressure for all tyres of size 5.00-5; 10 ply rating is 88 psi (6.1 bar).

According to the aircraft manufacturer's AFM, in the section on handling, care, maintenance, the correct pressure is 6.0 bar (87 psi).

1.3.2.5 Additional information on the choice of tyres

According to the Goodyear tyre manufacturer's aircraft tyre data book, section 4 data section-tyres, there are three tyres of the size 15x6.0-6 (part no. 156E66-1, Flight Custom II; part no. 156E61-3, Flight Special II; part no. 156E66-4, Flight Custom III) which have identical dimensions and which differ only in terms of their permitted maximum rated speed. The tyres listed by the aircraft manufacturer in the spare parts catalogue (part no 156E61-3) for the DA 42 aircraft has, according the aircraft tire data book, a rated speed of 120 miles per hour (mph), whilst the two other tyres mentioned have a rated speed of 160 mph.

In the Goodyear homepage, the tyre with part No. 156E66-4, Flight Custom III, is suggested for use on the DA 42 aircraft. According to the aircraft manufacturer, they are not aware why this tyre is recommended and supplied for the DA 42 aircraft.

Another aircraft manufacturer, which originally used the Goodyear Flight Special II tyres for its aircraft types, includes the following in a Technical Information on the choice of tyres, among other things [translated from German]:

"The tyre type 15x6.00-6 FS II (Flight Special II), P/N 156E61-3, which is used on various [name of the manufacturer] aircraft, is now of limited availability.

As an alternative, the tyre type 15x6.00-6 FC III (Flight Custom III) P/N 156E66-4 or 15x6.00-6 FS II (Flight Special II) P/N 156E66B1 can be used.

***CAUTION:** Mixed tyre configurations are not permissible."*

The tyre manufacturer Goodyear states that the two part numbers 156E61-3 and 156E66B1 designate the same tyre, the Flight Special II. The only difference is that the tyre with part number 156E61-3 is manufactured in the United States of America and the tyre with part number 156E66B1 is manufactured in Brazil.

1.4 Findings after the accident

1.4.1 Airframe

After the gear-up landing, it was possible to lift the aircraft using slings and a crane. Operation of the gear extension lever produced the same result as during the flight. It was possible to extend the nosewheel and the right main landing gear. The left main landing gear moved slightly but remained in the retracted position.

After a specialist in the DA 42 aircraft from the Motorfluggruppe Zürich (MFGZ) moved a screwdriver back and forth between the tyre and the wheel well in the wing, the left main landing gear dropped down into the extended position.

It was possible to reproduce this state. It was apparent that the left wheel was grazing the inner wall of the corresponding wheel well in the wing. Even after the tyre marks were cleaned off, scratch marks were still visible (Annex 1).

1.4.2 Main landing gear

Two different types of tyre were fitted to the right and left main landing gear wheels. The right wheel was fitted with a "Goodyear" brand tyre, part No. 156E66-4 and the left wheel was fitted with an "Air Hawk" brand tyre, part No. 33031. The latter has a different cross-section and unlike the Goodyear tyre, which has two grooves, it has four grooves.

Figure 1: Left wheel
Tyre marking:
"AIR HAWK
15X600-6
Type B III TSO-062d
6 PLY RATING MAX LOAD 1950 LBS
PART NO 33031"

Figure 2: Right wheel
Tyre marking:
"FLIGHT CUSTOM III
15X6.0-6
Goodyear
6 PLY RATING 160 MPH
LOAD RATING 1950 LBS
P/N 156 E 66-4"

A pressure of 4.7 bar was measured in the left tyre and 4.6 bar in the right tyre.

1.4.3 Information from the tyre manufacturer

The manufacturer of the Air Hawk tyre mentions the typical tyre characteristics in its information, but does not provide any information on minimum or maximum outer diameters, nor does it mention the aircraft types on which the 15X600-6 tyre is to be used.

As mentioned above, the Goodyear homepage states under P/N 156E66-4 that this tyre can be used on the DA 42 aircraft.

1.5 Maintenance on the aircraft

1.5.1 General

At the time of the accident, maintenance of aircraft HB-LUO was performed by the FAST company on Grenchen aerodrome. This company was founded in 2005. It originated from the earlier company, FARNER Air Services SA, and carries out maintenance work on aircraft and helicopters on Grenchen aerodrome. In addition it offers product development and certification, mainly for the aviation industry.

According to the owner and operator of the aircraft, it was envisaged to switch from the maintenance provider in Grenchen to a maintenance company in Zurich (MFGZ) and to continue to have only the daily maintenance carried out in Grenchen.

This change took place in July 2010, three months after the accident.

1.5.2 Work on the landing gear

On 13 April 2010, as part of the preparation work on aircraft HB-LUO, the tyre on the left main landing gear was changed. Between 13 April and 19 April 2010 no landings were performed. In the authorised release certificate (FAA Form 8130-3, airworthiness approval) it is confirmed that the supplied tyre type 15x6.00-6 and part number 33031 fulfils the required design data and guarantees safe operation: *"Certifies the items identified above were manufactured in conformity to: approved design data and are in a condition for safe operation"*. However, it is also stated that the person fitting the tyre must check whether it is suitable according to the applicable technical data: *"The installer must cross-check eligibility with applicable technical data"*.

The question as to why a tyre with a part number different to that specified by the aircraft manufacturer in the illustrated parts catalogue was fitted was addressed by one of the mechanics responsible who said that he had chosen the tyre in accordance with the specified dimensions of 15x6.00-6.

1.5.3 Additional information

According to information from mechanics in the maintenance company in Zurich there had already been problems on an earlier occasion with the landing gear of a DA 42 with the same operator and owner. During maintenance work on the aircraft, which was jacked up, irregularities were found in the operation of the landing gear. The right gear became partially lodged in normal operation and completely lodged in emergency operation.

It emerged that a tyre with an incorrect part number had been fitted. This situation was remedied and the maintenance company in Grenchen was informed. The persons responsible in the maintenance company in Grenchen stated that they would not recall that. The tyres had been discussed only once in general terms – without mentioning any specific case. However, they said they no longer recalled any details, and operation of the landing gear on aircraft which were jacked up had never caused them any problems.

1.6 Tests and research

1.6.1 Tests and clarifications on the aircraft manufacturer's premises

On the Diamond aircraft manufacturer's premises, the Air Hawk tyre from the aircraft involved in the accident was fitted onto a main landing gear wheel rim. The outer diameter was measured at different tyre pressures and the following overview emerged:

Tyre pressure	Outer ø	According to Goodyear aircraft tyre data book
3.9 bar (57 PSI)	38.60 cm	
4.1 bar (59 PSI)	38.83 cm	
4.3 bar (62 PSI)	38.90 cm	
4.5 bar (65 PSI)	38.93 cm	Flight Special II tyre:
4.7 bar (68 PSI)	38.96 cm	At 68 PSI maximum 15.2 in (38.6 cm)
4.9 bar (71 PSI)	39.10 cm	
5.1 bar (74 PSI)	39.13 cm	

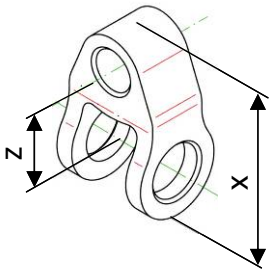
In addition, the dimensioning of the wheel well in the wing was examined on the aircraft manufacturer's premises. This is formed from plastic as a fixed component of the wing and according to the construction drawings has a diameter of 400 mm, with a tolerance of ±4 mm.

The measured diameter of the wheel well on the aircraft involved in the accident varied between 400 and 404 mm.

The wheel well of the landing gear on other aircraft in production was also measured. It was 400 ±0 mm in all cases.

According to the aircraft manufacturer's statement, in the dimensioning phase a clearance of 5 mm around the tyre was used for calculations. According to the drawing in the aircraft maintenance manual (AMM), 32-10-00 page 240a figure 7A: main landing gear tyre clearance measurement, the minimum distance from the tyre to the wheel well is specified as 4 mm (0.16 in).

Centring of the wheel in relation to the wheel well is set permanently by the factory and is not changed by the maintenance company. This setting is determined by the assembly of the main landing gear joint (MLG joint), which according to the manufacturer has a nominal dimension (z) of 32 mm between the two axes. The MLG joint is available in three different oversizes so that the wheel can be centred in relation to the wheel well. According to the manufacturer, MLG joints of different sizes can be used on the left and right landing gear.



MLG joint (dimensions in mm)

-51 joint:	x=59; z=32
-52 joint oversize 1:	x=61; z=34
-53 joint oversize 2:	x=63; z=36
-54 joint oversize 3:	x=65; z=38

MLG joint, according to AMM 32-10-00 page 209c, 30 Jun 2010
part number: D60-3217-23-51/52/53/54

Figure 3: Main landing gear joint (MLG joint)

In July 2010, a temporary revision (AMM-TR-MÄM 42-447) dated 30 June 2010 was published by the aircraft manufacturer containing instructions regarding replacement of the MLG joint. This publication was issued in connection with mandatory service bulletin No. MSB 42-088/1, effective from 5 July 2010, which requires an inspection of the MLG joint and which had the following objective, according to work instruction WI-MSB 42-088: *"This work instruction describes the inspection of the joints that connect the MLG (main landing gear) damper with the trailing arm for cracks."*

In this work instruction it is explicitly mentioned that when changing the MLG joint firstly one of the same size (nominal dimension (z), or corresponding oversize) must be fitted and secondly the minimum distance of 4 mm between the tyre and the wheel well must be checked when the landing gear is retracted. Such a check is not required for a normal tyre or wheel replacement (AMM 32-40-00, page 204 dated 30 June 2008).

1.6.2 Tests on the aircraft

After the accident, aircraft HB-LUO was jacked up in the Motorfluggruppe Zürich maintenance workshop and various landing gear functions were applied.

The starting point was as follows:

- Fitting of the Air Hawk tyre (from the aircraft involved in the accident) onto the left wheel, tyre pressure 4.5 bar according to AMM. Measured outer diameter 39.02 cm.
- New Flight Custom III tyre on the right wheel, tyre pressure 4.5 bar, according to AMM. Measured outer diameter 37.72 cm (according to the Goodyear aircraft tyre data book, the outer diameter may be between 36.96 cm and 38.61 cm).

It was possible to reproduce the landing gear malfunction as it occurred during the accident. The left wheel became lodged and only retracted following a delay and a jolt. The right wheel could be retracted without any problems and met the requirement of a minimum circumferential clearance of 4 mm.

When the landing gear was extended, the left wheel remained lodged in the wheel well. It must be assumed that the second profile groove of the tyre was resting on the edge of the wheel well (Annex 2). Only when a screwdriver was moved back and forth between the tyre and the corresponding wheel well, did the left main landing gear fall into the extended position.

The two wheels were then swapped over and the operation of the landing gear was again checked. It was possible to extend and retract the landing gear without any problems. With the landing gear retracted, the Air Hawk tyre on the right wheel met the requirement for a circumferential clearance of 4 mm between the tyre and the wheel well. The Flight Custom III tyre fitted to the left wheel did not meet this requirement. Over a section measuring approx. 6 cm, this clearance was max. 3 mm (Annex 2).

Moreover, measurement of the distance between the centre of rotation of the trailing arm and the axle of the wheel indicated a distance of 10.5 cm on the left landing gear compared to a distance of 9.8 cm on the right landing gear.

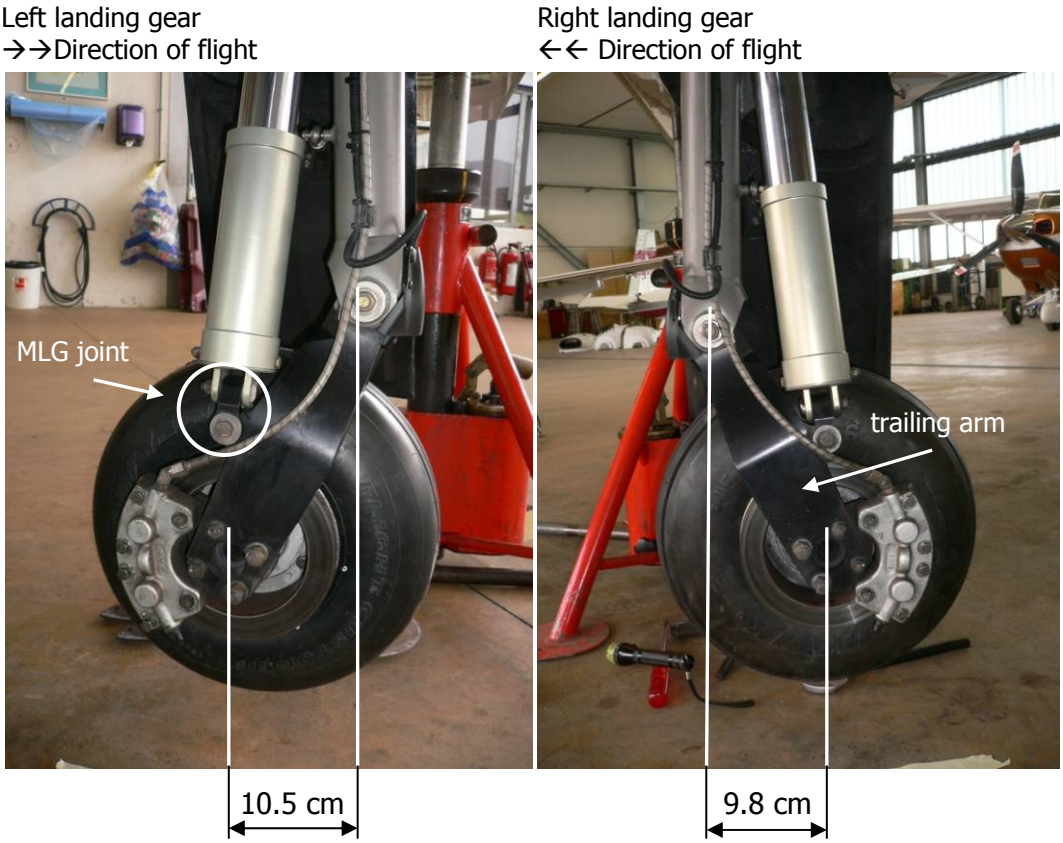


Figure 4: Left and right landing gear legs of aircraft HB-LUO

The mandatory service bulletin mentioned in chapter 1.6.1 was carried out on aircraft HB-LUO after the accident: the two MLG joints did not require replacing On the left an MLG joint, oversize 3 (maximum oversize), was fitted (z=38 mm) and on the right an oversize 2 joint was fitted (z=36 mm).

1.7 Manufacturer's emergency procedure

In the aircraft manufacturer's airplane flight manual (AFM), in the section on *"emergency procedures"* (Doc. No. 7.01.05.E) a procedure for a gear-up landing is published (cf. Annex 3).

An analogous procedure is published in the emergency + abnormal checklist (cf. Annex 4). This checklist (Edition # 14.4. GFC700), issued by Diamond Aircraft Flight Training Division differs from that in the AFM in that procedural instructions on reducing a possible risk of fire are not listed until the measures after touchdown.

One attempt by the crew to extend the landing gear was switching off the electrical power to the aircraft. While doing so they made the experience that the gear immediately extended in the asymmetric configuration.

The emergency procedure that corresponds to the powerless aircraft, *"complete failure of the electrical system"* (DA 42 AFM, page 3-48, dated 15-Nov-2007, Doc. No. 7.01.05-E) has beside other things the following information:

> ***NOTE***
> *The landing gear uplock is no longer ensured. The landing gear may slowly extend.*
> *The landing gear can be extended manually according to 3.6.2 - MANUAL EXTENSION OF THE LANDING GEAR.*

2 Analysis

2.1 Technical aspects

According to the aircraft manufacturer's documentation, the wheel well has a diameter of 400 mm, with a tolerance of ±4 mm. The tyre listed by the manufacturer in the part catalogue (part No. 156E61-3), the Goodyear Flight Special II type, has a maximum outer diameter of 38.608 mm. Hence, if the tolerances are exhausted, with a centred wheel, there remains a circumferential clearance of at least 5 mm in the wheel well. If the landing gear leg moves from the centre by only one millimeter, the tolerance limit of 4 mm for circumferential clearance is reached. The Air Hawk brand tyre fitted and involved in the accident, with a measured diameter of 38.93 cm, would under these conditions not comply with the circumferential clearance of 4 mm even if the wheel were centred.

As the subsequent investigation on the aircraft indicated, it was possible to extend and retract the right main landing gear without any problems even with the Air Hawk tyre. This is because the wheel was precisely centred in relation to the wheel well and the wheel well had a diameter of 400 mm. Consequently there remained a circumferential clearance of 5 mm.

Conversely, on the left landing gear, which was not precisely centred, it was apparent that the Flight Custom III tyre was below the 4 mm circumferential clearance by one millimeter over a section measuring some 6 cm (Annex 2). This tyre had an outer diameter of 37.72 cm. Even a tyre approved by the manufacturer would therefore contact the wheel well if it had the maximum permissible outer diameter of 38.608 cm. Moreover, the scratch marks in the wheel well (Annex 1) indicate that tyres must have grazed the wheel well at an earlier point in time.

Furthermore, the measurements of the distance between the wheel axle centre and the pivot point of the trailing arm produced a difference of 7 mm (figure 4). If, on the left landing gear, instead of 10.5 cm, this distance had measured 9.8 cm as on the right landing gear, the circumferential clearance would have been guaranteed regardless of the choice of tyre on aircraft HB-LUO. Such a reduction in the distance can, for example, be achieved with an oversized MLG joint. In the present case, however, the left landing gear leg was already fitted with an MLG of the maximum oversize. This clearly was not sufficient, under the circumstances, to centre the leg of the landing gear in relation to the wheel well.

Landing gear is naturally subjected to great mechanical stresses, which may lead to minor deformations. The tyres too may be deformed, for example as a result of prolonged immobilisation, braking action or external influences. All these influences should not adversely affect the operation of retractable landing gear.

In the present case, it was apparent that the left main landing gear was not centred. If one assumes that it was aligned correctly by the manufacturer when the aircraft was delivered, the displacement of the landing gear leg must have occurred in the course of operation.

A fundamental question is therefore posed: whether it is appropriate to design a retractable landing gear and its well with such a small circumferential clearance, as in the present case.

Centring of the landing gear is not generally adjusted by maintenance companies. This is shown, for example, by mandatory Service Bulletin 42-088/1, which requires the fitted MLG joint to be replaced with one of the same length if it has cracks.

The measurement procedure to check the 4 mm clearance between wheel and wheel well described both in this service bulletin and in the aircraft maintenance manual in (AMM) section 32-10-00 contains a fundamental error. It takes no account at all of the fact that the outside diameter of the tyre may vary. If it happens that this main landing gear clearance measurement is carried out with a tyre which has a relatively small outer diameter, any incorrect centring of the landing gear leg will remain undetected. If, at a later point in time, a tyre is fitted with an outer diameter at the upper tolerance limit, this may, as in the present case, cause the wheel to lodge in the wheel well.

2.2 Human and operational aspects

2.2.1 Crew

When the crew of HB-LUO realised that according to the indication the left main landing gear was not extended and locked, they called HB-LUK, an aircraft which was in operation on the same flying instructors' course, to determine the position of the landing gear from outside. This action, as well as the implemented aircraft manufacturer's procedures and the contact made with specialists on the ground, including the flying manoeuvres, indicate that the crew acted in a well-thought-out manner, one which exhausted all the possibilities.

The decision to land at Zurich Airport was appropriate and created the best possible situation regarding possible risks before and after the gear-up landing. Shortly before landing the crew acted according the measures mentioned in the AFM in order to minimize the risk of fire. However they refrained from switching off the electrical master switch. Refraining from switching off the electrical power did not correspond with the respective emergency procedure. Since the crew experienced an asymmetric extension of the landing gear after switching off the electrical power, it was circumspect to refrain from switching off the electrical power. With this the crew ensured that they could perform a gear up landing with a completely retracted landing gear.

The aircraft touched down with no bank attitude, which meant that the aircraft touched down mainly on the entrance steps and engine cowling respectively the exhaust pipes, so the bottom of the fuselage, with the antennas fitted to it, was virtually undamaged.

2.2.1 Maintenance company

The maintenance company changed the tyre on the left main landing gear on 13 April 2010. The fact that a tyre with a part number which did not correspond to that in the illustrated parts catalogue was installed is not indicative of prudent maintenance.

As the persons responsible within the maintenance company stated, they had chosen the new tyre exclusively on the basis of size. In principle this should be possible, but in such a case the approval of the manufacturer should be sought. This was not done in the present case.

It is difficult to comprehend how a maintenance company released an aircraft for operation on which two tyres of such different profiles were fitted (cf. figures 1

and 2). Not for nothing, a different aircraft manufacturer states for example in a Technical Information, among other things: "***CAUTION:*** *Mixed tyre configurations are not permissible."*

The fact that an identical choice of tyre had already caused problems on an earlier occasion shows that the operating procedures in the maintenance company, or rather the handling of incidents with the introduction of appropriate measures, were not optimal.

2.2.2 Aircraft manufacturer's procedures

The accident has shown that it was possible to avoid substantial damage to the engines by shutting down both engines shortly before landing. In addition, this action reduced the risk of a possible outbreak of fire after the landing.

The fact that the manufacturer's AFM refers to this possibility is appropriate and leaves it to the pilot to decide whether he wants to shut down the engines shortly before landing on the basis of all the facts.

The checklist published by the aircraft manufacturer specifies that these measures are to be implemented only after touchdown. The two procedures therefore exhibit a contradiction. The reference in the checklist to the effect that this does not replace the AFM is of little help to a pilot in such a phase, especially as the DA 42 aircraft is licensed for operation by a single pilot.

2.2.3 Aircraft manufacturer's publications

In the aircraft manufacturer's illustrated parts catalogue, the tyre with part No. D60-9032-17-02 is specified as item 150 for the main landing gear tyre. The following note is found under Remarks: type 156E61-3. This note corresponds to the part number of the Goodyear tyre (Flight Special II), which is fitted in the factory by the aircraft manufacturer and which was approved for the DA 42 aircraft.

On aircraft HB-LUO, a Goodyear tyre with the part number 156E66-4 was fitted to the right main landing gear. According to the Goodyear homepage, this Kevlar-reinforced tyre (Flight Custom III) is explicitly approved for the Diamond DA 42 aircraft. The aircraft manufacturer does not know why this type of tyre is recommended and supplied for the DA 42.

This uncertainty in choice of tyre should not be permitted by the aircraft manufacturer. In principle, it should be possible for any tyre of the corresponding tyre size to be fitted. If this is not possible, the aircraft manufacturer's illustrated parts catalogue should definitely mention which part number(s) are approved.

The fact, that the gear is no longer locked in the retracted position and can partially or totally extend when the electrical power is switched off, has to be mentioned in this context. The present accident has confirmed this and the respective emergency procedure for a total electrical power loss does also point out this fact. The fact that the manufacturer in his emergency procedure in the AFM *"landing with gear up"* recommends, besides shutting off the engines and switching off the fuel selectors also recommends to switch off the electrical master switch includes a considerable danger, especially by an asymmetric gear trouble. The gear does not stay in the retracted position anymore and the crew has no possibility left to change anything on this situation.

3 Conclusions

3.1 Findings

- The aircraft was licensed for VFR/IFR transport.
- The investigation revealed that the left main landing gear leg, respectively the wheel axle were not centred in relation to the wheel well.
- In the aircraft maintenance manual for the type DA 42 there is a procedure for checking the clearance between the wheel and the wheel well. However, this procedure does not take into account the fact that the outer diameters of tyres may be of different sizes.
- On the left landing gear leg an MLG joint with the maximum oversize 3 was fitted; on the right, a joint with oversize 2 was fitted. This corresponded to the original factory setting.
- On 13 April 2010, the maintenance company fitted a tyre to the left main landing gear whose size corresponded to the tyre specified by the aircraft manufacturer.
- The tyre fitted on 13 April 2010 was from a different manufacturer to the one specified in the aircraft manufacturer's illustrated parts catalogue.
- The pilots were in possession of the necessary licences for the flight.
- There are no indications of the pilots suffering any health problems.
- The crew's attempts to extend the gear were appropriate to the situation and corresponded to the aircraft manufacturer's instructions.
- The crew's decision to make a gear-up landing at Zurich Airport was reasonable and appropriate to the situation.
- The procedure specified in the manufacturer's checklist for emergencies and abnormal conditions for a gear-up landing differs from that in the airplane flight manual.
- The weather had no influence on the accident.

3.2 Cause

The accident is attributable to the fact that the aircraft had to make a landing with the landing gear up, because the left main landing gear could not be extended.

Causal for this landing gear malfunction was the fact that the left main landing gear was not centred in relation to the wheel well, so the tyre became lodged in the wheel well.

The following factors contributed to the accident:

- The procedure specified by the aircraft manufacturer for checking the clearance between the wheel and the wheel well was inadequate.
- The fact that a tyre was fitted to the left landing gear wheel which deviated slightly in terms of outer diameter and cross-section from that specified by the aircraft manufacturer.

4 Safety recommendations and measures taken since the accident

According to the provisions of Annex 13 of the ICAO, all safety recommendations listed in this report are intended for the supervisory authority of the competent state, which has to decide on the extent to which these recommendations are to be implemented. Nonetheless, any agency, establishment or individual is invited to strive to improve aviation safety in the spirit of the safety recommendations pronounced.

In the Ordinance on the Investigation of Aircraft Accidents and Serious Incidents (OIAASI), the Swiss legislation provides for the following regulation regarding implementation:

"Art. 32 Safety recommendations

The federal office shall inform the bureau within six months of publication of the investigation report of the measures which are being taken on the basis of the safety recommendations in the investigation report or of the reasons why these measures are not being implemented."

4.1 Safety recommendations

4.1.1 Safety deficit

As part of a flying instructor training course, at 14:23 UTC on 19 April 2010, the Diamond DA 42 aircraft, registration HB-LUO, took off from Lausanne on a training flight under VFR. On board were a flying instructor in the left-hand seat and a flying instructor under advanced training in the right-hand seat. Another participant on the flying instructor course was in the rear seat as a passenger.

After an aerodrome circuit in Lausanne, followed by a low go-around, the crew flew into the Villeneuve-Aigle region to perform various flying manoeuvres. In the course of these exercises, the landing gear had to be extended. The aircraft was at an altitude of 6500 ft QNH.

It was possible to extend the right main landing gear and the nosewheel normally. The left main landing gear remained retracted because the tyre had become lodged in the wheel well. All attempts to change this state were unsuccessful and the crew decided on a gear-up landing in Zurich-Kloten.

One attempt in preparing the emergency landing was to switch off the electrical power to the aircraft. While doing so the crew switched off both alternators and the electrical master switch. The crew got the impression that the gear extended immediately after switching off the electrical power. Since there was no indication in the powerless cockpit, the crew of the HB-LUO let the condition be verified from outside by the crew of an escorting aircraft. The known condition of the asymmetrically extended gear was shown.

According to the design of the aircraft the gear is no longer secured in the retracted position and can partially or totally extend when electrical power is switched off. The experience of the HBLUO crew during the preparation of the gear up landing has confirmed this and the respective emergency procedure for a total electrical power loss does also point out this fact. The fact that the manufacturer at the time of the accident in his emergency procedure in the AFM *"landing with gear up"* besides shutting off the engines and switching off the fuel selectors also recommended to switch off the electrical master switch included a considerable danger, especially by an asymmetric gear trouble. The gear did not

stay in the retracted position anymore and a crew concerned had no possibility left to change anything on this situation.

In the present case the HB-LUO crew did not switch off the electric master switch in order to prevent an inadvertent extension of the jammed landing gear struts during landing. Touchdown took place at 17:01 UTC and the three occupants were able to leave the aircraft uninjured. The aircraft was damaged.

The investigation stated the following as the cause of this accident:

"The accident is attributable to the fact that the aircraft had to make a landing with the landing gear up, because the left main gear could not be extended.

Causal for this landing gear malfunction was the fact that the left gear was not centred in relation to the wheel well, so the tyre became lodged in the wheel well.

The following factors contributed to the accident:

- *The procedure specified by the aircraft manufacturer for checking the clearance between the wheel and the well was inadequate.*
- *The fact that a tyre was fitted to the left landing gear wheel which deviated slightly in terms of outer diameter and cross-section from that specified by the aircraft manufacturer."*

4.1.2 Safety recommendation No. 438

The Federal Office for Civil Aviation (FOCA) respectively the European Aviation Safety Agency (EASA) should ensure that on the Diamond DA 42 aircraft type, sufficient circumferential clearance is guaranteed between the main landing gear wheel well and the wheel, so that lodging of the wheel is not possible in normal operation.

4.2 Measures taken since the accident

4.2.1 By the maintenance company in Grenchen

The responsible persons in the maintenance company in Grenchen stated that since the accident they would only fit Goodyear Special II type tyres to the DA 42 aircraft.

4.2.2 By the aircraft manufacturer

As a reaction to the accident the manufacturer got the tire manufacturer to do the following measures:

According to the aircraft manufacturer's statement the recommendations of the Flight Custom III tire (part No. 156E66-4) for the DA 42 aircraft on the Goodyear homepage was not in agreement the aircraft manufacturer. In a telephone conference call, dated 1 December 2010, between the aircraft manufacturer and Goodyear the latter was informed that for the time being the Flight Custom III tire is not released for the DA 42 aircraft.

Dated 27 May 2011 the aircraft manufacturer has published the AMM-TR-MÄM 42-47c & AMM-TR-MÄM 42-452/b revision in which a supplementary point was added. In future the minimum distance of 4 mm between the tyre and the wheel well must also be checked by a normal tyre or wheel replacement

The aircraft manufacturer also mentioned in an additional letter, dated 27 May 2011 the following:

"Die Anweisungen des DA 42 AFM im Falle einer Landung mit eingezogenem Fahrwerk werden in die Unterlagen der Diamond Aircraft Training Division aufgenommen."

[The instructions in the DA 42 AFM in case of a gear up landing will be implemented in the documents of the Diamond aircraft training division].

Furthermore the manufacturer, as a reaction to the investigation findings, has changed the emergency checklist. It is no longer recommended to switch off the electric master switch shortly before touchdown when a gear up landing is performed. This prevents the gear from extending again. This change has been published by the manufacturer in the *TEMPORARY REVISION TR-MÄM* 42-542 (Doc.#7.01.06-E), dated 4 July 2011, as follows:

3.6.3 LANDING WITH GEAR UP

NOTE

This procedure applies if the landing gear is completely retracted.

1.	Approach	with power at normal approach airspeeds and flap settings
2.	POWER lever	IDLE / just before touchdown

If the time / situation allows, the following steps can help to reduce the risk of fire:

3.	ENGINE MASTER	both OFF
4.	FUEL SELECTOR	both OFF

Touchdown:

5.	Touchdown	Contact surface with minimum airspeed
6.	On ground	Maintain directional control with rudder as long as possible so as to avoid collision with obstacles

Immediately after touchdown:

7.	ELECT. MASTER	OFF

NOTE

If the ELECT. MASTER is switched OFF before touchdown the landing gear will extend slowly.

END OF CHECKLIST

4.2.3 By the tire manufacturer Goodyear

In a telephone conference call, dated 1 December 2010, between the aircraft manufacturer and Goodyear the latter was informed that for the time being the Flight Custom III tire is not released for the DA 42 aircraft.

This recommendation on the Goodyear homepage is withdrawn. For the Flight Custom III tire (part No. 156E-66-4) the following aircraft type is recommended: "GUA" (general utility aircraft).

Payerne, 15 June 2011 Aircraft Accident Investigation Bureau

Annexes

Annex 1: Marks on the wheel well in the left wing

Figure 5: Before the tyre marks were cleaned off

Figure 6: Remaining scratch marks after the tyre marks were cleaned off

Annex 2: Tests on the aircraft

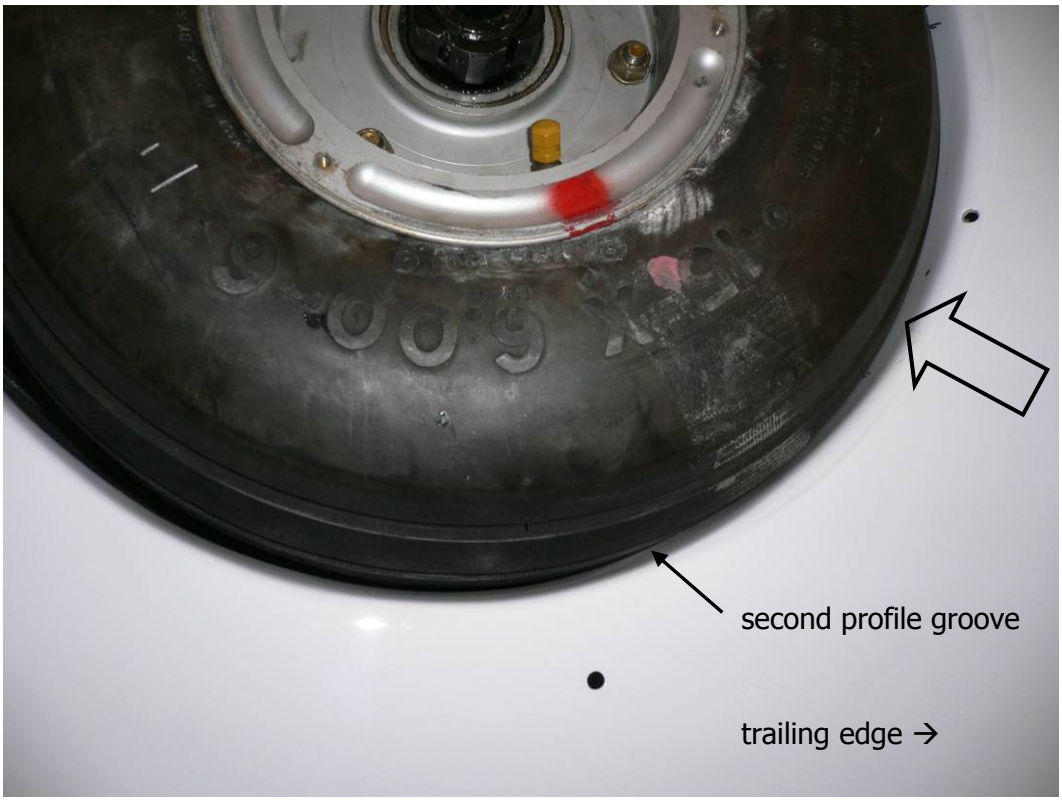


Figure 7: Air Hawk tyre on the left landing gear

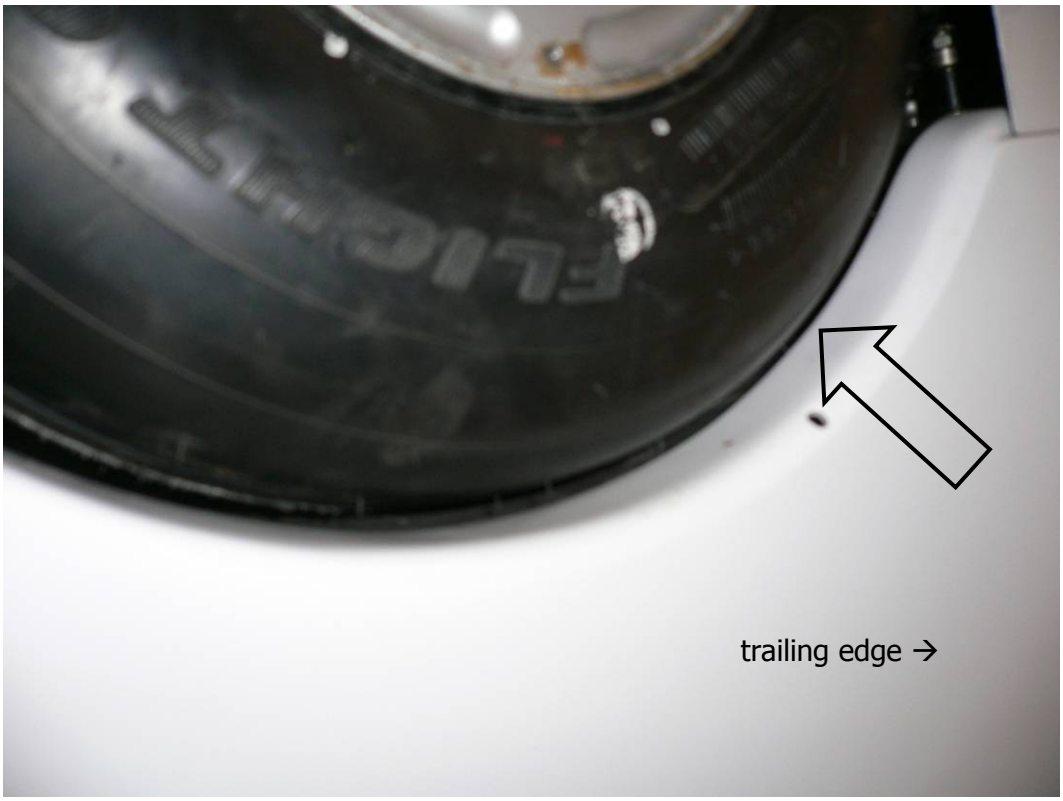


Figure 8: Flight Custom III tyre on the left landing gear

Annex 3: AFM – Manufacturer's procedure

3.6.3 LANDING WITH GEAR UP

NOTE

This procedure applies if the landing gear is completely retracted.

1.	Approach	with power at normal approach airspeeds and flap settings
2.	POWER lever	IDLE / just before touchdown

If the time / situation allows, the following steps can help to reduce the risk of fire:

3.	ENGINE MASTER	both OFF
4.	FUEL SELECTOR	both OFF
5.	ELECT. MASTER	OFF

Touchdown:

6.	Touchdown	Contact surface with minimum airspeed
7.	On ground	Maintain directional control with rudder as long as possible so as to avoid collision with obstacles

END OF CHECKLIST

Annex 4: Procedure in the manufacturer's checklist

LANDING GEAR UP LANDING

(Landing gear completely retracted)

1	Approach	NORMAL	1
	Just before touchdown:		
2	Power lever	IDLE	2
	After touchdown:		
3	Engine Masters (2)	OFF	3
4	Fuel selectors (2)	OFF	4
5	Electric Master	OFF	5

Annex 5: Aircraft after gear up landing