

# Investigation Report

## Identification

Type of Occurrence:	Accident
Date:	13 September 2006
Location:	Frankfurt / Main
Aircraft:	Airplane
Manufacturer / Model:	Fokker BV / Fokker F 28 MK 100
Injuries to Persons:	None
Damage:	Aircraft severely damaged
Other Damage:	None
Information Source:	Investigation by BFU
State File Number:	BFU AX002-06

## Factual Information

### History of the Flight

The Fokker F 28 MK 100 departed Paris with five crew and 86 passengers on board for a scheduled flight to Frankfurt / Main.

At 1941 hrs<sup>1</sup> the airplane touched down on runway 25L with a speed of approximately 130 kt.

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<sup>1</sup> All times local, unless otherwise stated

According to crew statements the co-pilot conducted a normal approach and touchdown was smooth. At the beginning of the rollout phase the airplane was decelerated with the thrust reverse at normal braking action. At about 100 kt the crew observed vibrations of moderate intensity. The Pilot in Command (PIC) initially presumed a burst tyre. Directly afterwards the crew observed strong vibrations of the main landing gear. The PIC instructed the co-pilot to stop the airplane using emergency reverse. At about 60 kt he took over controls and stopped the airplane on the runway centreline in the area of taxiway Hto. The co-pilot informed the controller by transmitting an urgency message. The controller mentioned that he had, for a short time, seen smoke in the area of the main landing gear.

The cabin crew received the instruction to get prepared for a potential evacuation. The airplane left runway 25L, taxied into taxiway Hto and stopped in front of taxiway C. The crew decided that a regular deboarding was to take place and informed the passengers accordingly.

According to the recordings of the Flight Data Recorder (FDR) vertical acceleration values between 1.15 and 0.83 occurred. The ground spoilers were deployed and the thrust reversers activated. About two seconds after touch down lateral acceleration of a maximum of +/- 0.8 and heading changes which did not cease until the aircraft stopped 40 seconds later were recorded. The Cockpit Voice Recorder (CVR) recorded vibrations which started two seconds after touch down and whose frequency was initially 15 Hz and later decreased.

## Personnel Information

The PIC, age 44, held an Airline Transport Pilot's License (ATPL(A)) valid until 2 May 2010, initially issued on 18 February 2004 by the French civil aviation authority. His license included the type rating and TRI for the aircraft type F 70/100. His medical class 1 certificate was valid until 31 December 2006. At the time of the accident he had a total flight experience of about 12,500 hours, of which 2,300 hours were on the type.

The co-pilot, age 44, had a total flight experience of about 3,800 hours; 1,310 hours of which were on the type. He held an Airline Transport Pilot's License (ATPL(A)) valid until 17 June 2009. He had a type rating for the aircraft type F 70/100. His medical class 1 certificate was valid until 31 October 2006.

## Aircraft Information

The Fokker F 28 MK 100 is a short and medium range twin jet aircraft.

The aircraft had been registered in France and since March 1999 had been operated by a French operator.

Manufacturer:	Fokker BV
Type:	Fokker F 28 MK 100
Year of manufacture:	1995
Manufacturer's Serial Number (MSN):	11494
MTOW:	42,000 kg
Engines	Rolls Royce TAY 650-15

Total operating hours of the aircraft were approximately 20,365 hours.

The main landing gears were fitted with shimmy dampers.

According to the statements of the operator, the dampers on the left main landing gear had been installed during an A-Check on 4 September 2006 and had been in operation for 44 hours. The maintenance schedule states that checking the level in the hydraulic oil reservoir is part of the daily check.

## Meteorological Information

At the time of the landing it was twilight.

The following weather prevailed according to ATIS, information H broadcast at 1922 hrs:

Clouds:	CAVOK
Visibility:	More than 10 km
Wind velocity:	100° / 3 kt
Temperature:	26°C
QNH:	1,013 hPa

Within the control zone (CTR) Visual Meteorological Conditions (VMC) prevailed.

## Aerodrome information

Frankfurt Airport has two parallel runways with magnetic directions of 069°/249° which are 4,000 m long and 60 m wide and a third runway with a magnetic direction of 179°, 4,000 m long and 45 m wide. At the time of the occurrence runways 25L and 25R were in use.

## Flight Recorders

The aircraft was equipped with a FDR Fairchild F1000 and a CVR Fairchild A200S. The FDR recorded 380 parameters. The CVR had a recording capacity of two hours.

The recordings of both recorders were available for the investigation.

## Wreckage and Impact Information

After the occurrence the controller requested a runway inspection by airport personnel. Approximately 150 m prior to the intersection of taxiway H, approximately 200 m east of taxiway H and approximately 50 m prior to taxiway G four pieces of metal were found which belonged to the left main landing gear.

It was determined that the left main landing gear upper torque link lug was broken (refer to Appendix). Parts of the lug were found between the bolt and the upper torque link. The air - ground switches were torn off their mountings. The hydraulic oil reservoir of the shimmy damper was 3 mm away the refill marking. The entire area of the shimmy damper was wet with hydraulic fluid.

The left main landing gear was removed and shipped to the BFU in Braunschweig.

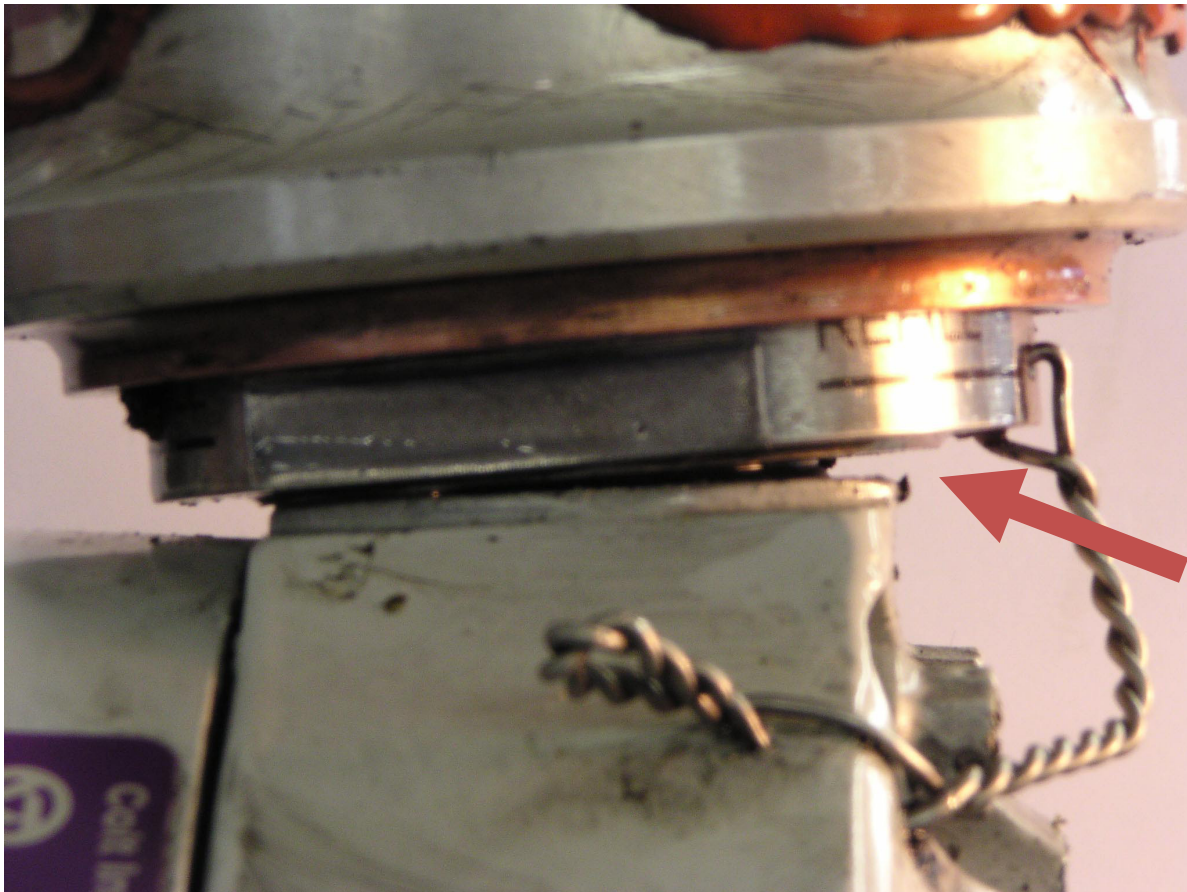
## Fire

There was no fire.

## Tests and Research

### Examination of the Shimmy Damper

Under the direction of the BFU an in-depth examination of the shimmy damper was conducted at one of the manufacturer's facilities. It was determined that the housing of the hydraulic oil reservoir showed minor traces of deformation and scratches. The screw connection between the oil reservoir and the shimmy damper was secured with a 1.2 mm strong lock wire. The lock wire was installed in the required direction. The reservoir could be turned manually in either direction within the space restricted by the lock wire length. Between the damper housing and the hydraulic reservoir one-sided gap of about 1.75 mm was found.



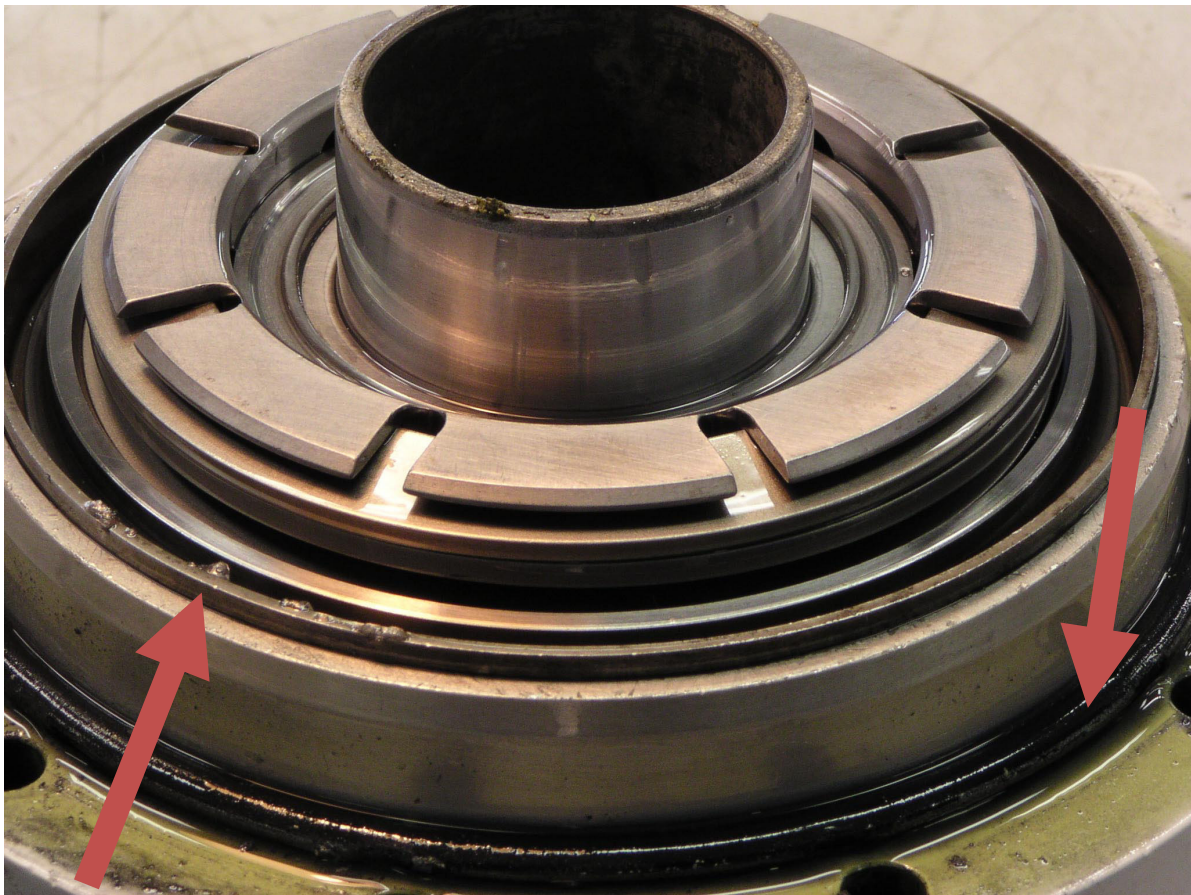
Connection hydraulic reservoir – damper housing with one-sided gap of 1.75 mm; Photo: Fokker Services BV

In the damper about 100 cm<sup>3</sup> slightly contaminated liquid was found. The liquid was seized for further investigation purposes.

An examination of the shimmy damper, onto which the reservoir had been fitted manually, to determine pressure and leak tightness revealed a leakage between damper housing and hydraulic reservoir.

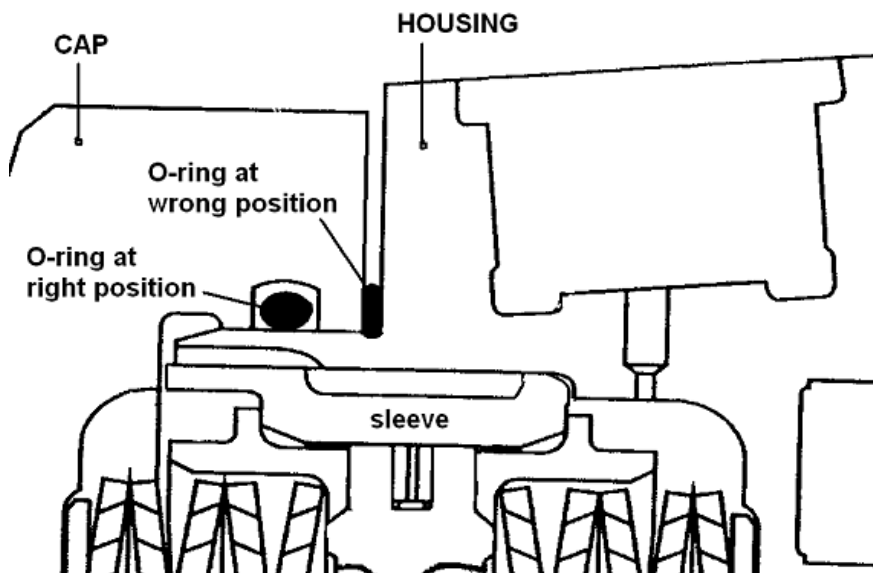
After the hydraulic reservoir was removed it became evident that the steel reservoir adapter was fitted askew into the damper housing.

During disassembly of the shimmy damper it was determined that the attachment bolts were torqued with values between 130-170 in.lb (14,7-19,2 Nm) (116-126 in.lb (13,1-14,23 Nm) was required). The O-ring between damper housing and cap was not installed in the groove inside the cap, but was clamped between housing and cap.



Damper casing with jelly-like substance and incorrectly mounted O-ring; Photo:

Fokker Services B.V.



O-ring as found during investigation Drawing

Fokker Services B.V.

The shimmy damper was emptied and disassembled. Thereby, residue of the jelly-like substance and dirt particles were found on all parts. In the area of the piston a metal chip the size of 2 mm was found.

The results of the flow tests, where the determined failures were gradually eliminated, showed that the incorrectly mounted O-ring and the contamination and/or the metal chip had an essential influence on the performance of the damper. The contamination and the metal chip caused an increase in flow rate of 0.8 Gallon Per Minute (GPM); whereas the incorrectly mounted O-ring led to an increase of 0.16 GPM.

The shimmy damper was cleaned, fitted with a correctly mounted O-ring and filled with hydraulic fluid. The function test revealed no failures.

### Examination of the Hydraulic Fluid

The seized hydraulic fluid was examined at the Wehrwissenschaftlichen Institut für Werk-, Explosiv- und Betriebsstoffe (WIWEB). This examination revealed that it was a product based on phosphate ester which is largely identical with Skydrol 500B-4. Water content and acid value were in the tolerance range of a used hydraulic fluid of this type. Neither aging nor decomposition was determined.

The black particles were identified as calcium phosphate, the jelly substance as Polyalkylmethacrylate. Both, the calcium phosphate and the Polyalkylmethacrylate were identified as contaminants.

The jelly substance from the inside of the shimmy damper was largely the same as the jelly substance from the hydraulic fluid.

### Additional Information

The shimmy damper had been in a French maintenance organisation between 6 July 2006 and 18 August 2006 for overhaul purposes. The overhaul was conducted at 11,494 cycles which is within the limit of 12,000 cycles. Since overhaul the damper had completed 49 cycles and since manufacture a total of 11,543 cycles.

The shimmy damper with the part number 23700-7 was in accordance with the latest technical standard of the manufacturer, at the time of the occurrence.

According to the statement of the damper manufacturer, the Component Maintenance Manual (CMM) requires a flow test after overhaul of the shimmy damper. The written documentation of the maintenance organisation showed that at least some of the tests required by the CMM were carried out. Results of the flow tests were, however, not documented. According to the documentation of the maintenance organisation these should have been carried out. The test criteria for a successful passing of the test documented in the documentation of the maintenance organisation stipulated a flow rate of less than 1.9 litres per minute (0.5 GPM). Since 2004, the test criteria in the manufacturer's CMM requires a flow rate not exceeding 1.5 litres per minute (0.4 GPM).

The aircraft manufacturer stated that in the past there had been 12 other cases where damage to the main landing gear had occurred. Five of these had resulted in damages to or fractures of the torque link lug, six of them had resulted in fractures of the main landing gears.

## Analysis

The pilots held the required licenses and ratings to conduct the flight.

The weather conditions had no causal effect on the course of events.

The FDR data did not show any evidence of a hard landing. Two seconds after touch down vibrations started which continued until the aircraft had come to a complete stop. The crew thought the vibrations were caused by a burst tyre. They managed to stay in the middle of the runway.

Generally, vibrations on the landing gear, e.g. during the landing, are not unusual. In order to minimise vibrations and avoid component fractures damping is necessary.

The fracture of the upper torque link lug was a forced rupture.

The examination of the damper showed that the incorrectly mounted O-ring in connection with the jelly-like substance and the metal chip within the damper housing caused the failure of the damping and then the fracture of the torque link.

The investigation results determined a contamination.

It is likely that the contamination occurred during the overhaul.

It was not possible to determine with absolute certainty whether or not a flow test was conducted after the overhaul of the damper. The written documentation of the

maintenance organisation regarding the conduct of the test did not contain the current requirements of the manufacturer's CMM. The damper would have passed a flow test conducted according to the obsolete documentation of the maintenance organisation. Had the current criteria of the CMM been applied, it would not have passed the test. It cannot be excluded that the use of obsolete requirements for the conduct of a test after overhaul is a contributory factor.

## Conclusions

The accident is caused by an incorrectly mounted o-ring and contamination of the hydraulic fluid which affected the shimmy damper's function. This resulted in a failure of the damping on the main landing gear and a forced rupture of the torque link.

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Braunschweig: 02 November 2011

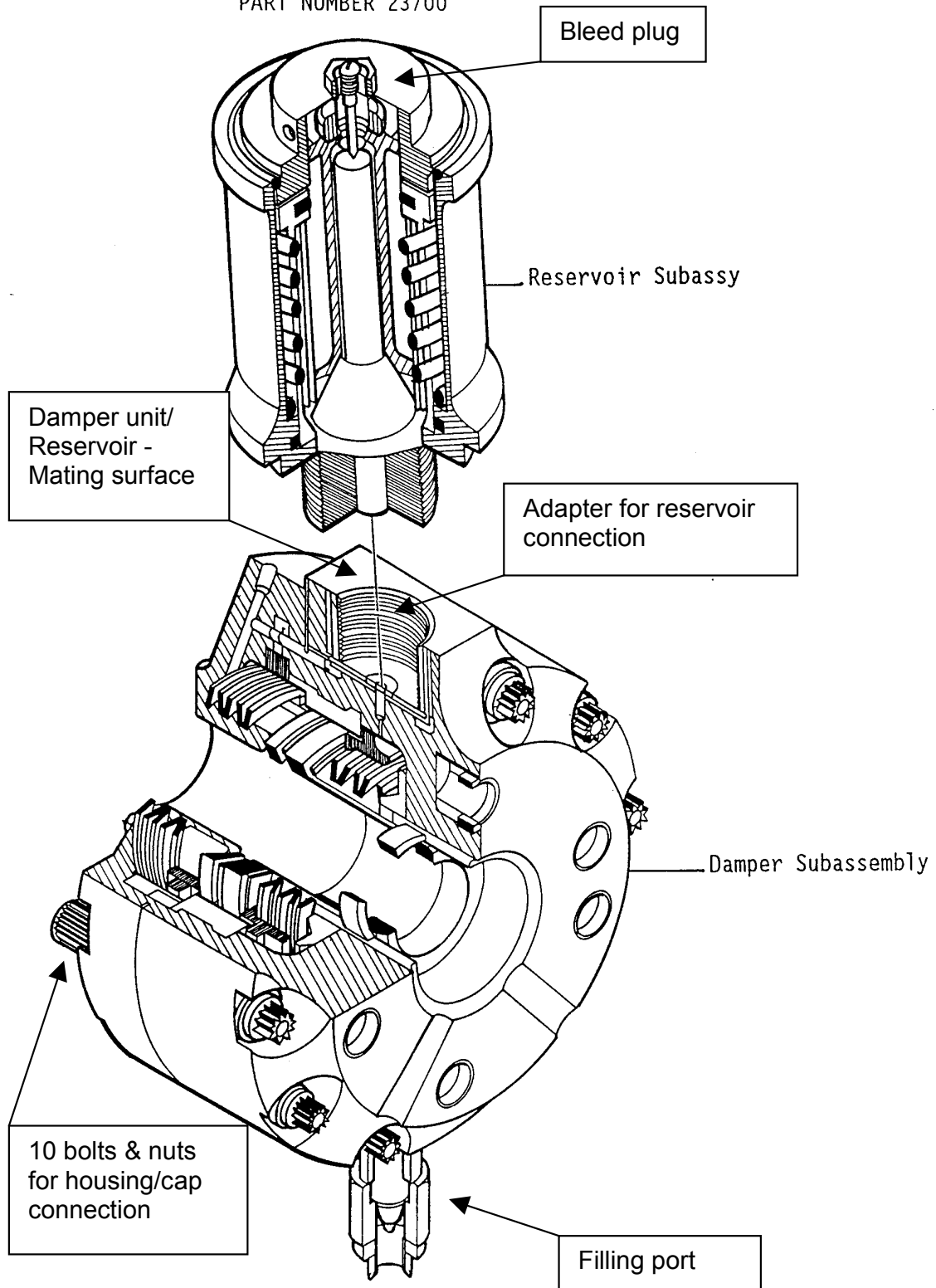
## Appendices

Appendix 1: Photos of the upper torque link lug and the shimmy damper of the left main landing gear

Appendix 2: Drawing of the shimmy damper



COMPONENT MAINTENANCE MANUAL  
PART NUMBER 23700



This investigation was conducted in accordance with the regulation (EU) No. 996/2010 of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation and the Federal German Law relating to the investigation of accidents and incidents associated with the operation of civil aircraft (*Flugunfall-Untersuchungs-Gesetz - FIUUG*) of 26 August 1998.

The sole objective of the investigation is to prevent future accidents and incidents. The investigation does not seek to ascertain blame or apportion legal liability for any claims that may arise.

This document is a translation of the German Investigation Report. Although every effort was made for the translation to be accurate, in the event of any discrepancies the original German document is the authentic version.

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