Bundesstelle für
Flugunfalluntersuchung

German Federal Bureau of
Aircraft Accident Investigation

Interim Report

Identification

Type of Occurrence:	Accident
Date:	30 September 2015
Location:	Saarbrücken
Aircraft:	Airplane
Manufacturer / Model:	Bombardier Inc./ DHC-8-402
Injuries to Persons:	None
Damage:	Aircraft severely damaged
Other Damage:	None
Information Source:	Investigation by BFU
State File Number:	BFU 15-1354-AX
Published:	December 2015

Factual Information

During take-off from runway 09 at Saarbrücken Airport the landing gear retracted in the rotation phase. The airplane came to a stop approximately 425 m prior to the end of the runway. It rested on the fuselage and was severely damaged. Persons were not injured.

History of the Flight

The crew of four was deployed for flights from Luxembourg (LUX) via Saarbrücken (SCN) to Hamburg (HAM) and back again via Saarbrücken to Luxembourg with a Bombadier DHC-8-402.

The crew stated that they had met at about 0530hrs[1] for pre-flight preparations. The flights up until the take-off in Saarbrücken had occurred without incident. All in all the working atmosphere had been good and relaxed and they had been ahead of schedule.

Saarbrücken was the destination airport for 14 passengers. The remaining 16 passengers' destination airport was Luxembourg.

According to the Cockpit Voice Recorder (CVR), the Flight Data Recorder (FDR), and the radio communication recordings, the engine start-up clearance was issued at 1009:47 hrs[2] approximately 25 minutes ahead of schedule. At 1015:03 hrs while taxiing on taxiway C, take-off clearance was issued. The Into Position Check was conducted at 1015:33 hrs on runway 09. The Pilot in Command (PIC) was Pilot Flying (PF) and the co-pilot Pilot Non Flying (PNF). The plan was to conduct take-off with reduced engine thrust (81%). During take-off the following callouts were made:

1016:24	PF	take off, my controls
1016:25	PNF	your controls
1016:27	PNF	spoiler is closed
1016:30	PNF	autofeather armed
1016:33	PF	looks like spring
1016:35	PNF	yeah, power is checked
1016:36	PNF	80 knots
1016:37	PF	checked
1016:40	PNF	V_1, rotate
1016:42	Background	click sound, probably gear lever UP
1016:43	PNF	upps, sorry

1 All times local, unless otherwise stated.
2 The times of the CVR recording were determined by means of radio transmission times

During the rotation phase with approximately 127 KIAS and a nose-up attitude of approximately 5°, the landing gear retracted. At 1016:44 hrs the airplane's tail had the first ground contact (tailstrike). The tailstrike warning light illuminated. Approximately 875 m after the initial ground contact the airplane came to a stop after it had bounced three times and skidded on the fuselage.

The cabin crew stated that due to smoke and fume development in the cabin the airplane was evacuated right away. All passengers and the crew were uninjured and left the severely damaged airplane without help.

Personnel Information

Pilot in Command (PIC)

The 45-year-old PIC held an Airline Transport Pilot's Licence (ATPL (A)) issued in Luxembourg in accordance with Part-FCL. The licence listed the type rating as PIC on DHC8 and the instrument rating; each valid until 29 February 2016.

His class 1 medical certificate was last issued on 30 June 2015 and valid until 05 July 2016.

He had a total flying experience of about 11,927 hours; of which 3,649 hours were on the type. In the last 90 days prior to the incident he had flown about 98 hours on the type.

Co-pilot

The 27-year-old co-pilot held a Commercial Pilot's Licence (CPL(A)) issued in Luxembourg in accordance with Part-FCL. The licence listed the type rating as co-pilot on DHC8 and the instrument rating; each valid until 31 July 2016. In addition the night flight qualification and Multi Crew Cooperation (MCC) training were listed.

Her class 1 medical certificate was last issued on 30 January 2015 and valid until 02 February 2016.

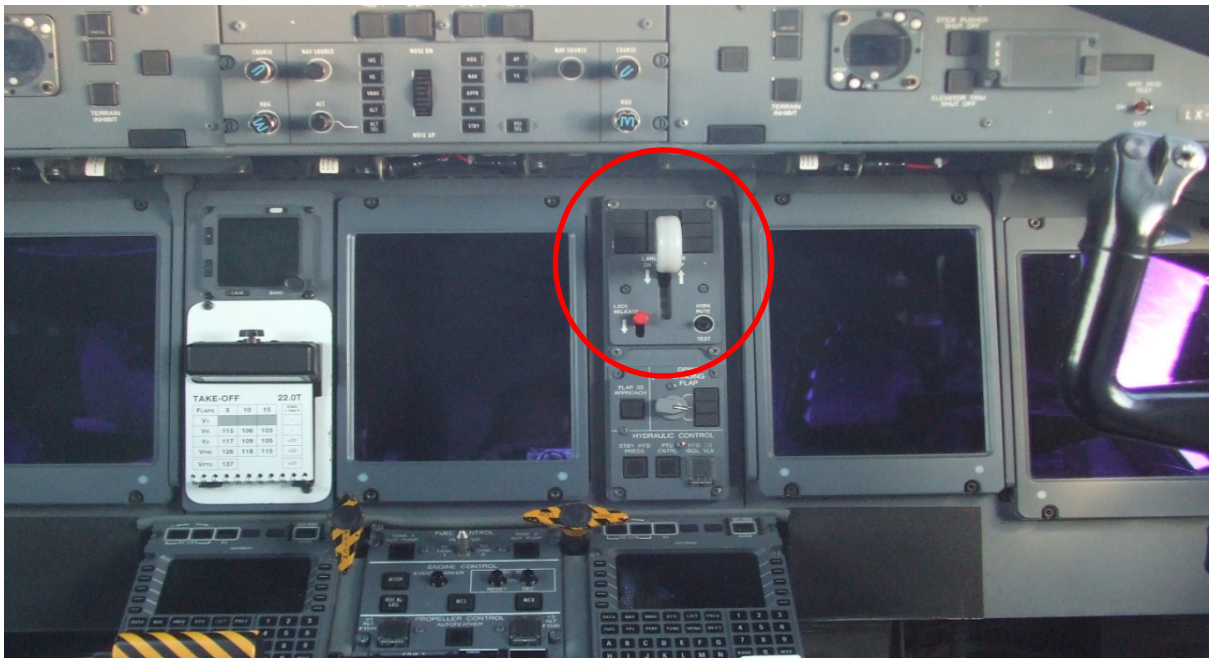
She had a total flying experience of about 3,295 hours. She had been PNF during approximately 1,200 flights. She had been flying on the DHC8 for about 1,483 hours. During approximately 580 flights she had been PNF. In the last 90 days she had flown about 161 hours on the type.

The day of the accident was the first day of flight duty after a 16-day vacation period.

Aircraft Information

The DHC-8-402 manufactured by Bombadier Inc. is a twin-engine turboprop transport aircraft in all-metal construction. The type certificate was issued in 1995. The airplane is a high-wing aircraft with T-tail configuration and equipped with two PW 150A engines manufactured by Pratt & Whitney Canada Inc. Maximum take-off mass is 28,990 kg.

The aircraft type is equipped with an electronically controlled hydraulic retractable tricycle landing gear with twin tyres. The main landing gears are retracted back into the engine cowlings mounted below the wings. The nose wheel retracts forward into the fuselage nose. A so-called Proximity Sensor Electronics Unit (PSEU) controls and monitors the retraction and extension process in combination with Weight-on-Wheels (WOW) sensors. The landing gear selector lever for the retraction and extension process is located in the cockpit area to the right of the centre. Indication lights indicate the positions of the wheel well doors and the landing gear. In order to actuate the landing gear lever the red Lock Release button has to be pushed simultaneously.



Position landing gear lever, Lock Release and indication lights in the cockpit Photo: BFU

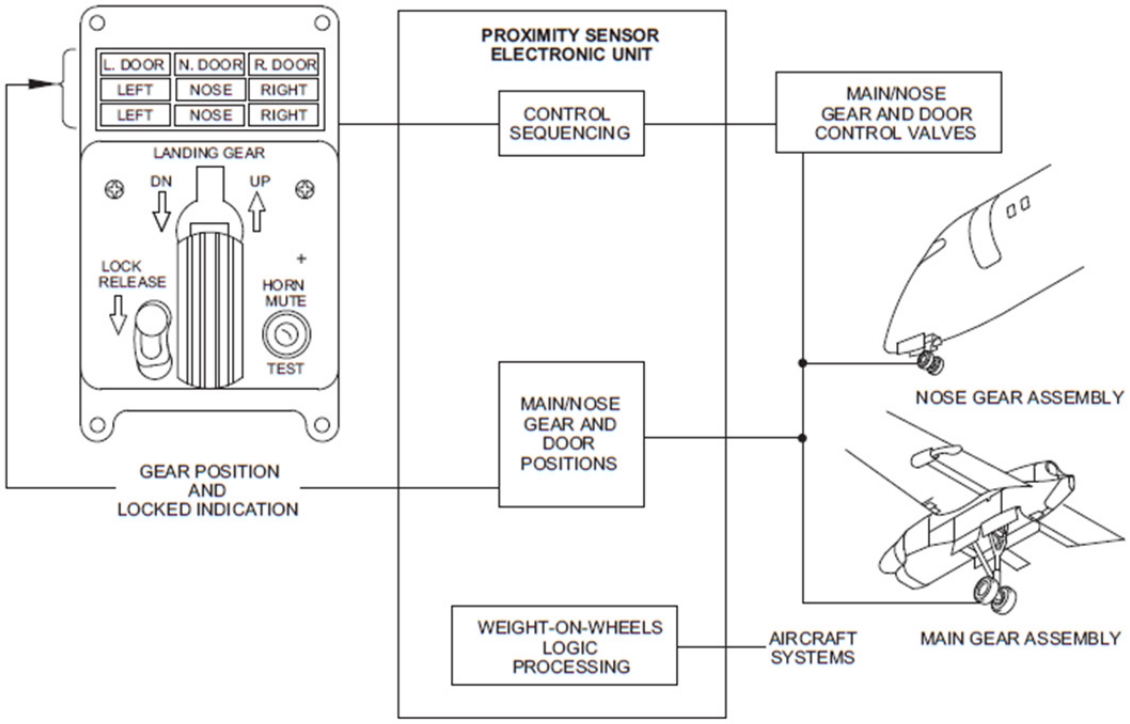
The V_{LO} (Landing gear operation) is 200 kt and the V_{LE} (Landing gear extended) 215 kt.

Schematic description of the manufacturer (Excerpt 12.13 (ATA 32) Landing Gear):

Retraction Sequence

When the landing gear selector lever is selected to the UP position, hydraulic pressure from No. 2 system is applied to the retract side of the system (Figure 12.13-19). This opens the nose gear forward doors and retracts the nose gear, it also opens the main gear aft doors and retracts the main gear. The aft nose gear doors are mechanically linked and close with the retracting nose gear. After nose gear retraction, the forward nose gear doors close hydraulically. The forward main gear doors are mechanically linked and close with the retracting main gear. After main gear retraction, the aft main gear doors close hydraulically.

The advisory light sequence during retraction starts with the LEFT, NOSE and RIGHT red unsafe lights and the amber selector handle light coming on. At the same time, the green LEFT, NOSE and RIGHT lights go off to show the gear is not locked down. The amber door advisory lights come on to show the hydraulically operated gear doors are open. When the landing gear is retracted and locked in the up position, the amber selector handle light and red advisory lights go out. Finally, the amber gear door advisory lights go out to show all the hydraulic gear doors have closed. No advisory lights should be on if the gear is up correctly. The main and nose gear are held in the up position mechanically with uplocks, and hydraulic pressure is removed from the system.



The aircraft type was certified in accordance with Part 25 Airworthiness Standards: Transport Category Airplanes. Certification specifications for the retractable landing gear are stipulated in Sec. 25.729 and CS 25.729 - Retracting Mechanism. These include stipulations for indications and warnings for the avoidance of landings without extended landing gear. Stipulations regarding the risk to retract the landing gear on

the ground are not included. The manufacturer and the European Aviation Safety Agency (EASA) stated that so far they have no information concerning similar accidents with the DHC-8-402.

The airplane involved, manufacturer's serial number 4420, year of manufacture 2012, had a certificate of registration issued in Luxembourg. The latest Airworthiness Review Certificate (ARC) was issued on 21 October 2014 valid until 30 October 2015. Total operating hours were about 7,131 hours. Take-off mass at Saarbrücken Airport was approximately 21,700 kg. The commensurate V_1 (take-off decision speed) was 112 kt and V_R (rotation speed) 115 kt.

Meteorological Information

At the time of the take-off the valid aviation routine weather report (METAR) of

0950 hrs of Saarbrücken Airport read:

Wind:	070°/15 kt, TEMPO 060°/15G25kt
Visibility:	More than 10 km
Clouds:	No clouds below 5,000 ft (CAVOK)
Temperature:	10°C
Dewpoint:	4°C
Barometric air pressure (QNH):	1,030 hPa

Radio Communications

Radio communications between the crew and Saarbrücken Tower were recorded and made available to the BFU for evaluation.

Aerodrome Information

Saarbrücken Airport (EDDR) is located 4 Nautical Miles (NM) south-east of Saarbrücken City. Aerodrome elevation is 1,058 ft AMSL.

The airport has one asphalt runway of 1,990 m length and 45 m width and a parallel grass strip which is 545 m long and 50 m wide. Both are oriented 086°/266°. Three taxiways (A, B, C) lead from the apron to the asphalt runway.

Flight Recorders

The Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR) were seized by and read out at the BFU.

FDR:

Manufacturer:	Universal Avionics
Type:	SSFDR
Part Number:	1606 – 00 - 01
Serial Number:	550
Recording:	260 Parameters, 500 Hours

CVR:

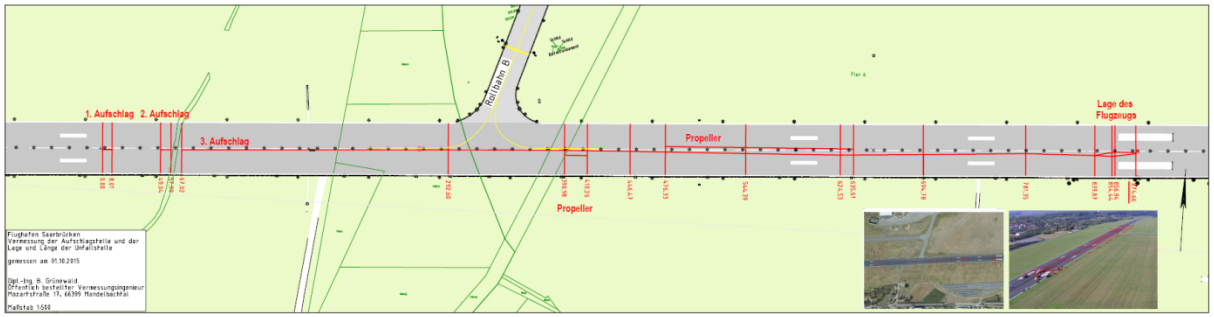
Manufacturer:	Universal Avionics
Part Number:	1607 – 00 - 00
Serial Number:	442
Recording:	4 mono data, 120 minutes

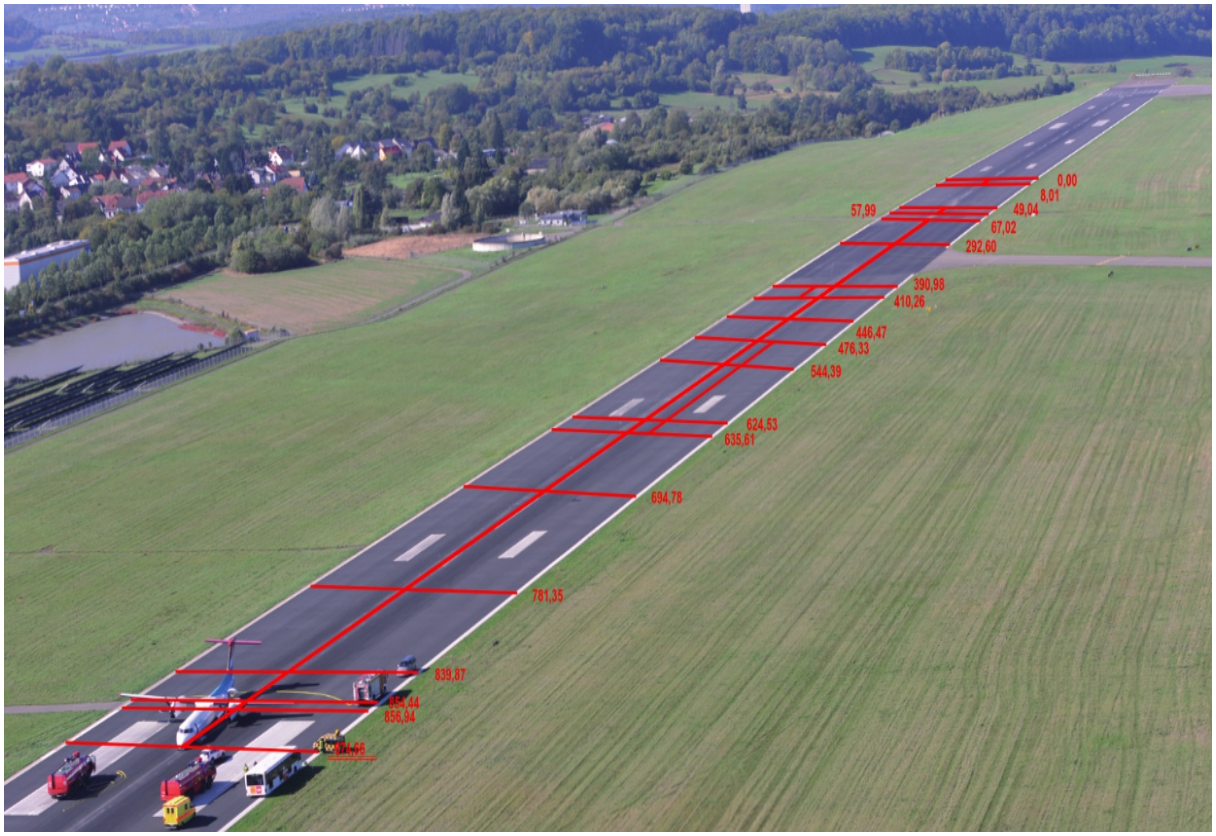
The recorders were undamaged. All recorded parameters were readable. Both reorders stopped recording at 1016:50 hrs prior to the airplane's standstill.

Therefore the G-switch, which switches off the power supply for the recorders in case of an accident, was removed for further examination.

Wreckage and Impact Information

The airplane bounced three times and skidded for a distance of approximately 807 m. It then came to rest abreast the PAPI of runway 27 approximately in the centre of the runway.





Overview skid marks and final position of the airplane Drawing and Photo: Airport

The airplane rested upright on the fuselage. The main landing gear was completely retracted and the wheel well doors at the engine cowlings closed. The nose landing gear was retracted. The front nose landing gear doors were open and damaged. The landing gear selector lever in the cockpit was in the position “Up”, i.e. retracted. The propeller blades of the left propeller were shortened by approximately 40 cm and the ones of the right by about 1 cm. Commensurate propeller impact marks were found on the runway. The left lateral fin below the fuselage was abraded by about 3 cm on the entire length. The fuselage’s bottom surface was scratched, dented and completely abraded, respectively, from about 2 m aft of the nose landing gear until the aft baggage compartment.

Damage on the fuselage's bottom surface (in flight direction) Photo: BFU

Approximately 1,630 kg fuel were on board the airplane. No fuel leaked from the airplane.

After the salvage operation the airplane was jacked up and the function of the retractable landing gear checked. The test was repeated several times and neither test showed any malfunction of the landing gear, the operation controls or indications.

It was determined that the landing gear already retracts if the nose landing gear is airborne (Weight-on-Wheel switches -> air) but the main landing gears are still on the ground (WOW sws -> ground). The system design responsible stated that this corresponded with the design logic.

Fire

There was no evidence of fire during the take-off run or after the accident.

Organisations and their Procedures

The operator had been approved by the Direction de l'Aviation Civile, Luxembourg.

The operator had made stipulations in the Operation Manual (OM) regarding procedures for crew cooperation during take-off, among others.

Part A Chapter 8.3.20 General Cockpit Procedures of the OM stipulated:

> *300 Co-operation between crew members*
>
> *Since crews are constantly changing, it is necessary to facilitate the teamwork by strict adherence to the […] Standard Operating Procedures, as prescribed in OM Part A and B.*
>
> *[…] crew members shall use standardized verbal callouts during each phase of flight. Standard callouts are used to improve crosscheck, coordination and mutual crew member awareness and are typically used to:*
>
> *Give command, delegate a task; acknowledge a command or confirm receipt of an information; Challenge and respond to checklist items; Call a change of an indication Identify a specific event; Identify exceedances. […]*

Part A Chapter 8.3.22 Cockpit Procedures of the OM stipulated:

> *100 General*
>
> *Take-off must only be performed under such conditions that it can be either safely discontinued or continued should an engine fail.*
>
> *The actual figures for V_1, V_R, V_2 shall be determined by both pilots individually and then be compared.*
>
> *These speeds shall be called out distinctly by the PNF. Callouts and procedures are contained in OM Part B for the respective aeroplane types.*

Standard take-off procedures as laid down in the operational documentation of OM Part B are based on operational capabilities of the respective aeroplane and noise abatement procedures.

Monitoring and cross-checking of the flight instruments during take-off and climb-out (especially in IMC or darkness) is a "must" for the following reasons:

take-off during darkness but in good visibility has led to accidents because the PF took his reference outside the cockpit only and perceived the take-off acceleration as a positive rate of climb.

take-off and climb-out procedures require considerable nose-high attitude. Should the artificial horizon of the PF fail in such a phase without being readily noticed, the aeroplane might come immediately into a very dangerous situation.

Since some instruments react slowly, only a continuous monitoring and cross-checking of all available flight instruments (especially the artificial horizon, IAS, rate of climb indicators and altimeter) provides the correct information for a particular situation. The PNF must help the PF to perform this difficult task and shall therefore restrict other cockpit work to the bare minimum required during take-off and the initial climb-out phase.

Part B of the OM stipulated operating procedures for the DHC-8-402. Chapter 2 contained checklists for normal procedures, describing texts, lists and callouts.

600 Take off roll callouts

CAPTAIN	COPILOT
After line-up, checks heading / elevation and announces: "**RUNWAY HEADING AND ELEVATION CHECKED**"	
	Replies: "**CHECKED**"
Just before advancing the power levers announces: "**TAKEOFF, YOUR / MY CONTROLS**"	
	Replies: "**YOUR / MY CONTROLS**"
Advances slowly the power levers to RATING detent.	
PF	**PNF**
	Observes spoiler advisory lights go out, PFCS indication on MFD show spoilers retracted and announces: "**SPOILERS CLOSED**"
	Checks A/F ARM annunciation on ED and announces: "**AUTOFEATHER ARMED**"
	Checks torque matching the torque bugs. Verifies normal engine indications and announces: "**POWER CHECKED**"
	At 80 KIAS announces: "**80 KNOTS**"
Replies: "**CHECKED**"	

The cross-check of the engine instruments during the takeoff roll is performed by the PNF.

700 Take off callouts

PF	PNF
	At V_1 announces: "**V_1**"
	At V_R announces: "**ROTATE**"
Rotates to 8° to achieve lift off. After lift off continues to a minimum pitch attitude of 10° to achieve V_{FTO}.	When positive climb is indicated on the flight instruments announces: "**POSITIVE CLIMB**"
Requests: "**GEAR UP**"	
Climbs with V_{FTO}.	Selects landing gear up and replies: "**GEAR UP SELECTED**"
	Checks gear up, no lights and announces: "**GEAR UP AND LOCKED**"
For FMS departure, requests: "**SELECT LNAV**"	
	Presses NAV, checks LNAV on FMA and announces: "**LNAV SELECTED**"
Requests: "**SELECT INDICATED AIRSPEED, SET V_{FTO}**"	
	Selects IAS, sets V_{FTO}, checks on FMA and announces: "**INDICATED AIRSPEED SELECTED, V_{FTO} SET**"

The PNF monitors flight instruments and flight path.

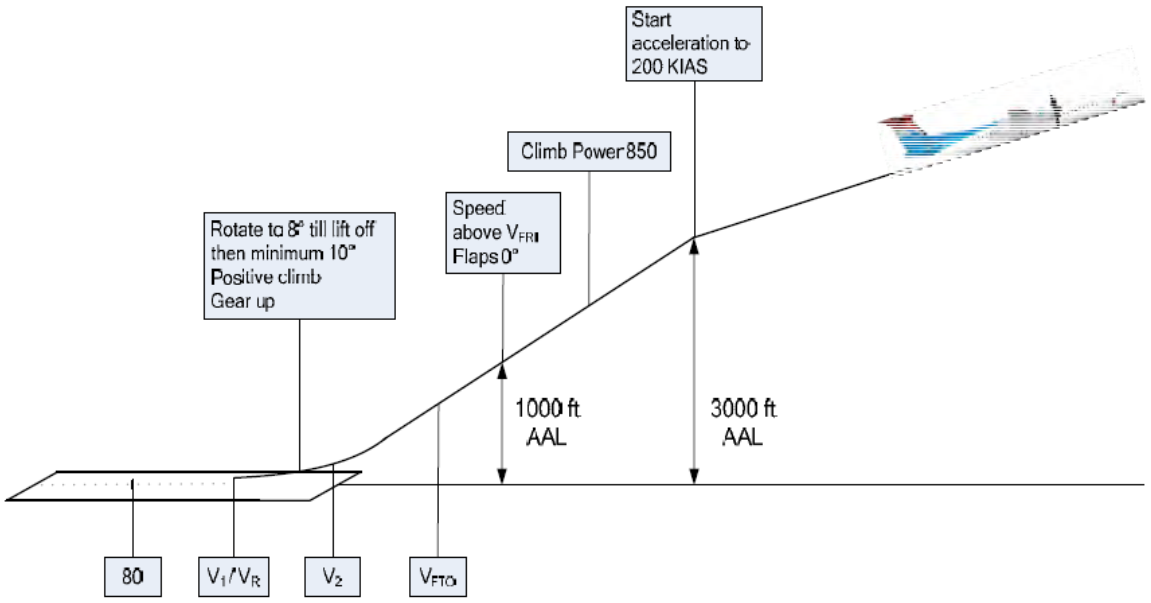
NOTE:

"**POSITIVE CLIMB**" will be announced when the flight instruments clearly indicate that the airplane is climbing (VSI, altimeter). This is particularly important when taking off in low visibility or low ceiling weather conditions.

900 Normal take off profile

The following profile summarize the major actions performed by the crew.

Callouts and additional actions to be performed by the crew are not detailed in the profile.



Chapter 3.5 Engine Failure in Take-off stipulated: *[…] The gear must be retracted as soon as a positive rate of climb is established. […]*

Additional Information

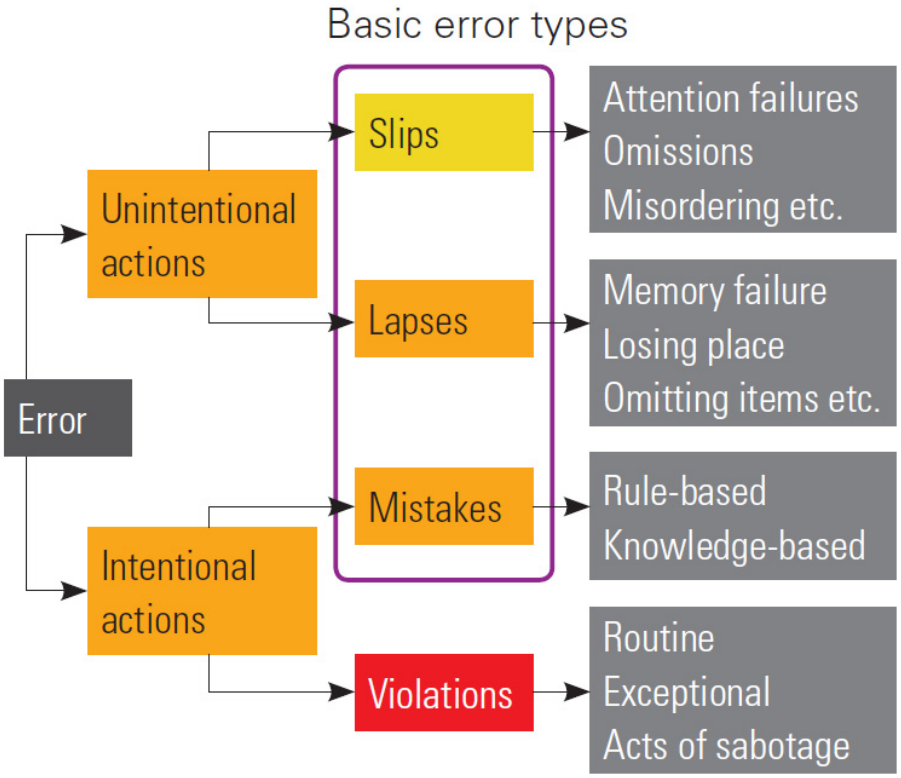
Due to the accident 30 flights from the last 3 months prior to the accident were randomly selected. Their Quick Access Recorder (QAR) data was examined regarding the retraction of the landing gear using the Operational Flight Data Monitoring Program (OFDM). In addition 10 take-offs from runway 09 at Saarbrücken Airport were examined. Furthermore, all flights (29) of the co-pilot since 05 August 2015 as PNF were examined. In all cases the time of the pitch application for rotation, the rate of climb, and the radar height were examined. The examination of the flights determined no indication that the landing gear lever was actuated too early.

Human Error:

Civil Aviation Safety Authority: SMS for Aviation–Human Factors a Practical Guide

Making errors is about as normal as breathing oxygen. (James Reason)

Error is a normal and natural part of everyday life—it is generally accepted that we will make errors daily. In fact, research suggests that we make between three to six errors every waking hour, regardless of the task being performed.



Managing error: If you want to find actual solutions for the problems human errors cause, you often need large systemic changes. […] Another way is for you to build error tolerance into the system—limiting the consequences of errors when they do occur. This involves adopting a broad organisational approach to error management, rather than focusing solely on the individuals making the errors. […]

For example, the most common types of errors (slips and lapses) involve attention, vigilance and memory problems. Therefore, developing procedures (checklists that act as memory aids), designing human-centred equipment (alarms and warning devices if operationally critical items are forgotten) and training programs to raise awareness of human factors issues, are all common tools.

Health and Safety Executive: Reducing error and influencing behaviour

Accidents can occur through people's involvement with their work. As technical systems have become more reliable, the focus has turned to human causes of accidents. It is estimated that up to 80% of accidents may be attributed, at least in part, to the actions or omissions of people. […] *We all make errors irrespective of how much training and experience we possess or how motivated we are to do it right. Failures are more serious for jobs where the consequences of errors are not protected. However, errors can occur in all tasks, not just those which are called safety-critical.*

Active failures have an immediate consequence and are usually made by front-line people such as drivers, control room staff or machine operators. In a situation where there is no room for error these active failures have an immediate impact on health and safety.

Errors fall into three categories: slips, lapses and mistakes. Slips and lapses occur in very familiar tasks which we can carry out without much need for conscious attention. These tasks are called 'skill-based' and are very vulnerable to errors if our attention is diverted, even momentarily. Driving a car is a typical skill-based task for many of us. Slips and lapses are the errors which are made by even the most experienced, well-trained and highly-motivated people. […]

Slips are failures in carrying out the actions of a task. They are described as 'actions-not-as-planned'. Examples would be: picking up the wrong component from a mixed box, operating the wrong switch, transposing digits when copying out numbers and misordering steps in a procedure. Typical slips might include: performing an action too soon in a procedure or leaving it too late; omitting a step or series of steps from a task […]

Everyone can make errors no matter how well trained and motivated they are. Sometimes we are 'set up' by the system to fail. The challenge is to develop error-tolerant systems and to prevent errors from occurring. […]

Airbus, Flight Operations Briefing Notes, Human Performance - Error Management:

Slips and lapses are failures in the execution of the intended action. Slips are actions that do not go as planned, while lapses are memory failures. For example, operating the flap lever instead of the (intended) gear lever is a slip. Forgetting a checklist item is a lapse. […]

Slips and lapses typically emerge at the skill-based level. There are several known mechanisms behind slips and lapses. It is known, for example, that mental "programs" which are most commonly used, may take over from very similar programs, which are less frequent or exceptional. […]

Slips are usually easy to detect quickly and do not have immediate serious consequences due to in-built system protections.

Lapses may be more difficult to detect, and therefore may also be more likely to have consequences. […]

One common false assumption is that errors and violations are limited to incidents and accidents. Recent data from Flight Operations Monitoring (e.g. LOSA) indicate that errors and violations are quite common in flight operations. According to the University of Texas LOSA database, in around 60% of the flights at least one error or violation was observed, the average per flight being 1.5.

A quarter of the errors and violations were mismanaged or had consequences (an undesired aircraft state or an additional error). The study also indicated that a third of the errors were detected and corrected by the flight crew, 4% were detected but made worse, and over 60% of errors remained undetected. This data should underline the fact that errors are normal in flight operations and that, as such, they are usually not immediately dangerous. […]

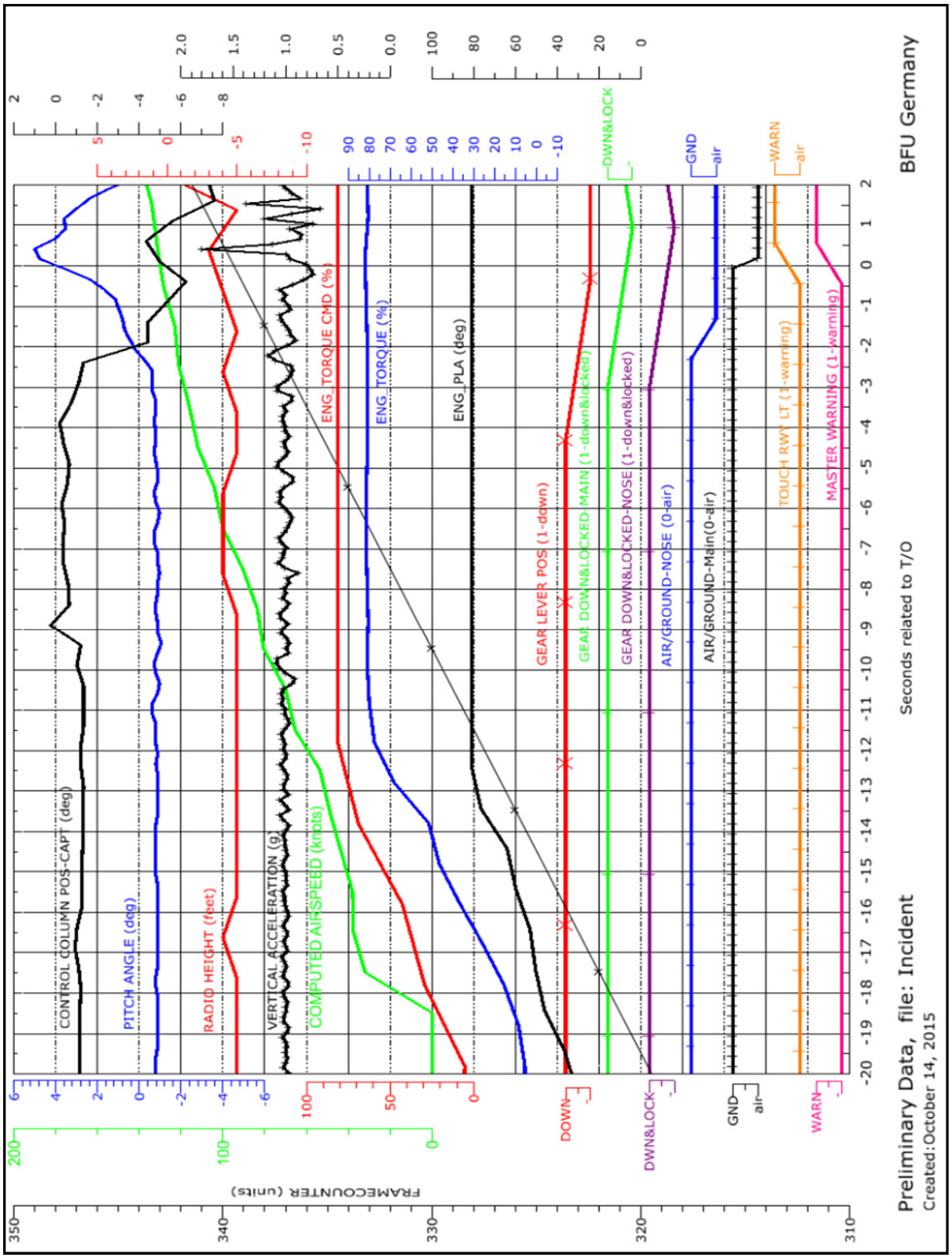
Real solutions for human error require systemic improvements in the operation. One way consists of improving working conditions, procedures, and knowledge, in order to reduce the likelihood of error and to improve error detection. Another way is to build more error tolerance into the system, i.e. limit the consequences of errors.

Error Prevention aims at avoiding the error all-together. This is possible only in some specific cases and, almost without exception, requires design-based solutions. […] Error Tolerance aims at making the system as tolerant as possible towards error, i.e. minimizing the consequences of errors.

Investigator in charge:	Axel Rokohl
Field investigation:	Thomas Karge, Axel Rokohl
Assistance:	Hans-Werner Hempelmann, Thomas Karge

Appendix

FDR data of the take-off run



This investigation is 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 - FlUUG*) 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.

Published by:

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