

Investigation Report

Identification

Type of occurrence:	Accident
Date:	18 November 2009
Location:	Emden
Aircraft:	Civil Air Transport
Manufacturer / Model:	Dassault / Falcon 900EX
Injuries to persons:	None
Damage:	Aircraft seriously damaged
Other damage:	Slight crop damage
Source of Information:	Investigation by BFU
State File Number:	BFU CX015-09

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.

Published by

Bundesstelle für
Flugunfalluntersuchung

Hermann-Blenk-Str. 16
38108 Braunschweig

Telefon 0 531 35 48 - 0
Telefax 0 531 35 48 - 246

Email: box@bfu-web.de

Internet: www.bfu-web.de

Contents	Page
Identification	1
Abbreviations	5
Summary	6
1. Factual Information	7
1.1 History of the Flight.....	7
1.2 Injuries to persons	10
1.3 Damage to aircraft	11
1.4 Other damage.....	11
1.5 Personnel Information.....	11
1.5.1 Pilot in command	11
1.5.2 Copilot.....	11
1.5.3 Cabin Crew	11
1.5.4 Flight Information Service	11
1.6 Aircraft Information	12
1.6.1 Engine and Airframe Maintenance.....	12
1.6.2 Brakes	12
1.6.3 Reverse Thrust.....	13
1.7 Meteorological Information	15
1.8 Aids to Navigation.....	16
1.9 Communications	17
1.10 Aerodrome Information	17
1.11 Flight Recorders	17
1.11.1 Flight Data Recorder	17
1.11.2 Cockpit Voice Recorder.....	18
1.12 Wreckage and Impact Information.....	18
1.13 Medical and Pathological Information	21
1.14 Fire	21
1.15 Survival Aspects	21
1.16 Tests and Research.....	22
1.17 Organisational and Management Information.....	22
1.18 Supplementary Information.....	22
1.19 Useful or Effective Investigation techniques	23

2.	Analysis	24
3.	Conclusions.....	30
3.1	Findings.....	30
3.2	Causes.....	31
4.	Safety Recommendations	31
5.	Appendices.....	32

Abbreviations

AIP	Luftfahrthandbuch	Aeronautical Information Publication
AFM		Airplane Flight Manual
ATPL	Lizenz für Verkehrspiloten	Airline Transport Pilot's License (Aeroplane)
BFU	Bundesstelle für Flugunfalluntersuchung	Federal Bureau of Aircraft Accident Investigation
CPL	Lizenz für Berufspiloten	Commercial Pilot's License (Aeroplane)
CRM		Crew Resource Management
CVR		Cockpit Voice Recorder
DFDR		Digital Flight Data Recorder
DWD	Deutscher Wetterdienst	German Meteorological Service Provider
FIUUG	Flugunfalluntersuchungsgesetz	Federal German Civil Aircraft Accident Investigation Law
ISP	Serviceperson an Bord	Inflight Service Personnel
MCC		Multi Crew Concept
METAR	Routinewettermeldung	Meteorological Aerodrome Routine Report
NDB	Ungerichtetes Funkfeuer	Non-directional Beacon
OM		Operating Manual
PF	Luftfahrzeugführer am Steuer	Pilot Flying
PM		Pilot Monitoring
RWY	Piste	Runway
SIGMET	Signifikante Wetterinformation	Significant Meteorological Information

TAF	Flugplatzwettervorhersage	Terminal Aerodrome Forecast
TCU		Throttle Control Unit
TRI/TRE		Type Rating Instructor/ Type Rating Examiner
VLP	Verkehrslandeplatz	Licensed Civil Aerodrome
WAFC		World Area Forecast Centre

Summary

At 11:28¹ on 18.11.2009 the German Federal Bureau of Aircraft Accident Investigation (BFU) was advised by the Flight Information Service provider at Emden Aerodrome (EDWE) that a Falcon 900EX had overrun the end of the runway after landing and that the nose landing gear had broken off. The BFU dispatched two investigators to the accident site. The occurrence was classified as an accident and investigated in accordance with the *FIUUG* Federal German Civil Aircraft Accident Investigation Law.

The following causal factors have been identified:

- The extended landing distance due to the increased approach speed, was not taken into account.
- The aircraft touched down too late on the runway.
- Consideration of a go-around came too late for action.
- The go-around was not carried out.
- The engine thrust was reduced too late.
- A faulty reverse thrust mechanism partly negated the effect of wheel brake operation, thereby extending the landing distance.

1. Factual Information

1.1 History of the Flight

At 10:48 the Falcon 900EX took off from Braunschweig (EDVE) with a crew of three and five passengers, for a flight in accordance with Instrument Flight Rules to Emden (EDWE). This was the first flight of the day both for crew and aircraft.

The approach to Runway 25 in Emden was flown as a non-precision (NDB) procedure. The aircraft was under radar guidance and in uninterrupted radio contact with the respective air traffic sector controllers. The initial contact was with Bremen Radar,

¹ all times local unless otherwise stated

which provided the following weather report and airfield information for Emden: "runway in use is 25, wind... 200 degrees, 15 up to 20 knots, gusts between 25 knots

and 30 knots, the visibility 9 kilometres, broken clouds 1 800 ft, overcast 2 400 ft, temperature 10, dew point 8, QNH 1006“. The flight crew confirmed receipt of the information.

The aircraft was then handed over for the approach to Wittmund Radar and remained under its control until hand-over to Emden Info. During the contact with Wittmund Radar, the controller asked if the crew had received the weather for Emden. The crew confirmed they had received this information. As then requested by the crew, the aircraft was given radar vectors to the NDB beacon and cleared for an NDB approach to Runway 25.

At 11:19, about 6 min. 30 s. prior to touchdown, Wittmund Radar handed over the aircraft to Emden Info (118.6 MHz) when the crew reported their intentions for approach and landing. The Emden flight Information service agent responded: "...runway 25 in use, 1006 QNH“. After the crew confirmed receipt, the agent reported the current wind as: "200, 15 up to 20, gusts 25 up to 30 knots“. About four minutes later, about 1 min. 30 sec. prior to touch-down, the agent transmitted another wind report of "200, 25 knots“, receipt of which was confirmed by transmission of the call-sign by the flight crew. There were no further radio communications until the aircraft came to a halt.

The flight crew subsequently reported the approach had been stable and uneventful, although the prevailing southwest wind was strong and gusty. The crew had calculated an approach speed (V_{ref}) of 116 kt for the landing weight of approx. 14,420 kg. However, given the reported wind speed and gusts, the crew had increased the approach speed V_{ref} to 128 kt (V_{bug}). The crew stated the runway had come into view on descending through about 1,700 ft. According to the flight data recorder (DFDR), the aircraft was then about 6.1 NM DME from the aerodrome.

Witnesses stated that the runway was wet; there were a number of large puddles on the left and right outer margins in the final quarter of the runway. The last 200 m of runway had a large puddle left of the centreline.

The approach and landing were flown in the configuration *slats out, flaps 40*. The crew completed the *Final* checklist. This included a test of the anti-skid-system and hydraulic indicators. The crew said that both were normal.

The aircraft touched down on Runway 25 at about 11:26. The DFDR flight recorder trace indicates that it took about 26 seconds from touchdown to come to a full stop.

Witnesses stated that the aircraft touched down about 200 metres after the threshold. Based on the DFDR flight data recorder log, the main landing gear touched down about 214 metres after the threshold. The DFDR speed log indicates that at this time the aircraft Calibrated Airspeed (CAS) was 124 kt and the Ground Speed 115 kt. The DFDR log also indicated that the thrust setting for all three engines was about 56% N1 and the thrust levers were set at an angle of about 45°.

After touchdown the Pilot Non-Flying deployed the airbrakes; the DFDR log indicates that the airbrakes were deployed about one second after touchdown. At the moment of touchdown the Pilot flying (PF) reduced the thrust of the two outer engines to idle; the DFDR log indicates that the two thrust levers were brought back to a setting of about 26°. The idle-speed of these two engines had reduced to about 28% N1 by about ten seconds after touchdown, to about 26 % N1 after 15 seconds, and 23% N1 after about 20 seconds.

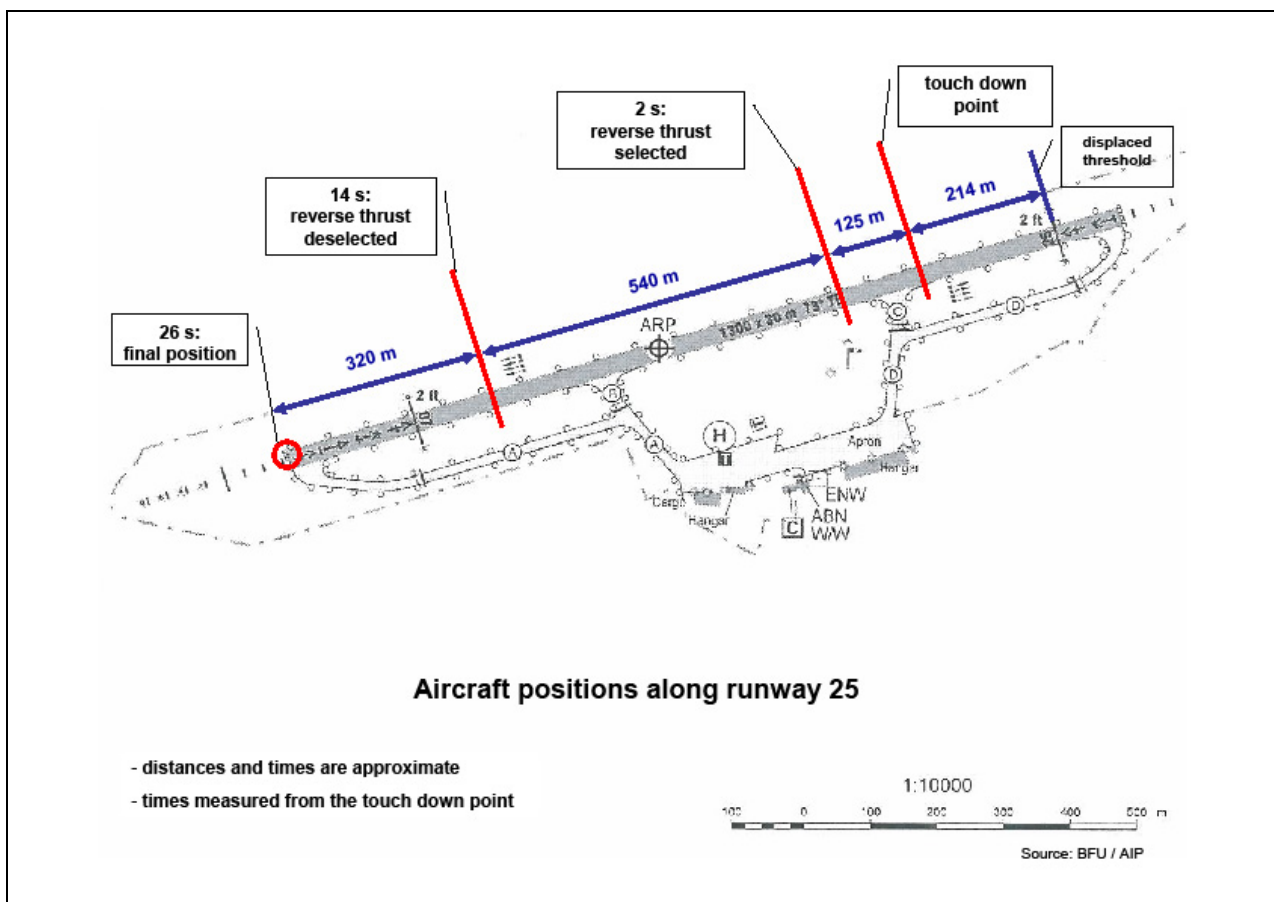
The centre engine thrust reverser was activated about 0.5 sec. after touchdown. The DFDR log for this function recorded a time lapse of 3.5 seconds from stowed to the deployed condition. The subsequent recording showed that the reverse thrust did not reach the fully deployed condition. Even so, further parameters showed that the reverse thrust was operated in accordance with the thrust lever setting (here approx. 80° and 82% N1).

The Pilot Flying called for a go-around about eight seconds and 430 m after touchdown. Within the next second both flight crewmembers cancelled this call with the words "*nee, zu spät*", bzw. „...*nee, nicht mehr*" ("No, too late", respectively "...no, no more").

The reverse thrust mechanism was deselected at a CAS speed of about 95 kt (80 kt ground speed), after having travelled about 665 metres along the runway and about 11 seconds after selection of the reverse thrust. The thrust lever record shows that it was reduced from an angle of about 80° to 21° (idle) in about 0.7 sec. The engine required about 3 seconds to reduce thrust to about 36% N1, at which point the CAS was about 45 kt and ground speed was about 34 kt. Thrust then declined further to about 33% N1, with no change in the thrust lever setting.

About 320 m of runway remained at the moment the reverse thrust was deselected. During the following seconds the flight crew attempted to brake the aircraft to a stop from a speed of about 95 kt CAS (80 kt ground speed). After having travelled about 900 m along the runway, the crew steered the aircraft towards the right. The crew

said it was their intention to avoid a collision with the runway lights located on the grass just after the hard runway. At this point, the DFDR recording shows the speed as about 62 kt CAS (49 kt ground speed). The aircraft rolled off the end of the hard runway at a ground speed of about 15 kt; 2.40 m from the runway edge it collided with a concrete plinth for Runway 07/25 approach lighting. The nose gear broke off, and the aircraft came to a stop one metre further on.



After the aircraft came to rest, the Captain ordered occupants to leave the aircraft with the words: "...Tür auf, Tür auf, und raus mit den Leuten, raus" ("Open the door, open the door, get everyone out!")

The cabin flight attendant then opened the passenger door on the fuselage front left. All those on board then left the aircraft via this door. There were no injuries.

1.2 Injuries to Persons

There were no injuries to persons.

1.3 Damage to Aircraft

The aircraft was seriously damaged.

1.4 Other Damage

There was slight crop damage.

1.5 Personnel Information

1.5.1 Pilot in Command

The 55 year-old pilot in command, acting as pilot flying (PF) that day, was in possession of an Air Transport Pilot's Licence (ATPL) issued in accordance with JAR-FCL (German). He was entitled to fly as pilot in command of the Falcon 900EX, also as a Type Rating Instructor on this aircraft. He was licensed for flights conducted in accordance with Instrument Flight Rules and Category 1 (CAT I) landings. His total flight time was about 18,400 hours, of which about 8,500 hours were on the type in question. His most recent simulator training had taken place in June 2009. His Class 1 Medical Certificate was valid to 13.01.2010.

1.5.2 Co-pilot

The 27 year-old co-pilot, acting as pilot monitoring (PM) that day, was in possession of a Commercial Pilot's Licence (CPL) issued in accordance with the requirements of JAR-FCL (German). He was licensed for flights conducted in accordance with Instrument Flight Rules and Category 1 (CAT I) landings. His total flight time was about 700 hours (including light aircraft about 3,500 hours), of which about 420 hours were on the type in question. His most recent simulator training had taken place in August 2009. His Class 1 Medical Certificate was valid to 03.01.2010.

1.5.3 Cabin Crew

The 33 year-old flight attendant had 1,523 hours total flight time, all on the Falcon 900EX. Her responsibilities were those of so-called In-flight Service Personnel (ISP).

1.5.4 Flight Information Service Agent

The 40 year-old flight information service agent had been employed at Emden civil aerodrome since 14.04.2000.

1.6 Aircraft Information

1.6.1 Engine and Airframe Maintenance

The Falcon 900EX is a low-wing jet aircraft with two main landing gears and a nose gear. The aircraft can accommodate up to 14 passengers. All three jet engines are installed in the rear fuselage. The centre jet engine has a thrust reverser unit.

The Falcon 900EX fuselage is 20.21 m long. The wingspan is 19.33 m and the aircraft stands 7.55 m high. It is classified in ICAO Fire and Rescue Category 4.

Aircraft Manufacturer:	Dassault Aviation
Type:	Falcon 900EX
Manufacturer's Serial Number:	65
Year of Manufacture:	2000
Max. take-off weight:	49,000 lbs
Max. landing weight:	44,500 lbs
Total airframe flight time:	6,619 hours
Total flight cycles:	2,746
Engines:	Honeywell TFE 731-60-1C

The aircraft was registered in the Cayman Islands on 01.07.2008, since when it had been used as a company aircraft for non-public transport operations.

The Certificate of Airworthiness was issued by the Cayman Islands Civil Aviation Authority on 01.07.2009 and valid to 30.06.2010.

The previous Basic Inspection had been completed on 22.09.2009 following 6,526 flight hours and 2,650 landings (flight cycles).

1.6.2 Brakes

The foot-operated wheel brakes on the main landing gear are activated using pedals. In normal operation, Hydraulic System 1 operates the wheel brake system, while Hydraulic System 2 operates the emergency braking system. In addition, the brakes are coupled to an anti-skid-system.

The cockpit controls include a three-position selector switch:

Position 1: “on #1” – normal braking with anti-skid system

Position 2: “off #2” – emergency braking with no anti-skid system

Position 3: “off #1” – normal braking with no anti-skid system

(Source: Dassault Aviation – Falcon 900EX, Operating Manual)

During the post-accident inspection by the BFU, the selector switch was at Position 1.

1.6.3 Reverse Thrust

The centre engine has a reverse thrust unit and is only approved for use on the ground. The Airplane Flight Manual issued by Dassault Aviation says that reverse thrust may only be selected after all three landing gears have touched down on the runway, and may continue to operate at full power until the aircraft has come to a complete stop.

The DFDR recorded two parameters:

- “in transit”: the engine reverse thrust doors open; during their deployment, the reverse thrust selector lever in the cockpit cannot be advanced beyond 'idle'.
- “deployed”: the reverse thrust doors are fully open; the reverse thrust selector lever in the cockpit is unlocked and the thrust lever can then be advanced from 'idle'.

If both parameters are “-“: the reverse thrust is de-activated and the engine reverse thrust doors are stowed.

The manufacturer's Maintenance Manual describes operation of the reverse thrust as follows:

C. Throttle Control Unit

Aircraft on the ground:

(1.) Deployment

Deployment is obtained by setting engine No. 2 throttle control lever to IDLE position and retarding the thrust reverser control lever.

The throttle control lever is then mechanically latched in IDLE position. During TR door movement, the TR control lever is electrically self-held in position.

NOTE: When the TR doors are fully deployed, the TR control lever can be moved to modify engine No. 2 power, thus creating the desired aircraft "deceleration effect".

(2.) Stow

As soon as the TR doors are fully deployed, the TR control lever can be advanced for TR doors stowing.

Engine No. 2 throttle control lever is unlatched when the TR doors are completely stowed.

The Maintenance Manual also contains this more detailed description of the operation:

(a.) Sequence initiation, overstop

The aircraft on the ground, TR doors stowed, and engine No. 2 throttle lever at IDLE, the TRCU (Thrust Reverser Control Unit) is connected to the ground through ground/flight relay and "engine No. 2 throttle lever at IDLE" signal from proximity sensor. The TR control lever on engine No. 2 throttle control lever may then be activated.

Selection by the pilot of the TR control lever to TR IDLE, initiates the following deployment sequence:

With the throttle control lever at 23°, proximity sensor is activated thus energizing relay through TRCU. Energized relay directly supplies (self-hold) electro-magnet from bus B2 through circuit breaker. Electro-magnet locks engine No. 2 throttle control lever in IDLE position. TRCU controls display of "TRANS" indication on EID through DAU 2 and energization of isolation electric valve of hydraulic control valve.

With the throttle control lever at 25°, proximity sensor is activated thus energizing the "stow" electric valve of hydraulic control valve from bus B2, through circuit breaker, unlatching proximity sensors in latched position and TRCU. TRCU energizes relay and the "unlatching" electric valve of hydraulic control valve. Relay energizes electro-magnet from bus B2. TR doors are in "overstow" cycle.

As soon as proximity sensors trip to "unlatched" position, the "stow" electric valve is de-energized and the "deploy" electric valve of hydraulic control valve is energized. TR doors are in "deploy" cycle.

(b.) Deploy

The "deploy" electric valve of hydraulic control valve is energized until the TR doors receive a stow command. When the TR doors are fully deployed, thrust reverser "deploy" proximity sensor tilts to "deploy" position (closed contact). TRCU cancels display of "TRANS" indication and triggers display of "DEPLOY" indication on EID through DAU 2.

The thrust reverser control lever may be advanced to TR FULL POWER position.

Extract from Falcon 900EX Operating Manual – Procedures, Normal Procedures, *after landing checklist* with use of thrust reverser:

AFTER LANDING	
– At touch down:	
• Airbrake handle	Position 2
Airbrake extension reduces lift and improves braking effectiveness during the high speed phase of the landing run.	
– Thrust reverser	As required
After touch-down, before using the thrust reverser, ensure that the airplane is firmly on ground on all 3 landing gears and that the airbrakes (if available) are extended.	
Ensure that engine 2 is effectively at idle power before setting the reverser lever to reverser idle; this is to avoid excessive loads being applied to the thrust reverser actuating mechanism.	
• Reverser lever	Reverser idle
• EICAS: TRANSIT annunciation	On then out – Checked
• EICAS: DEPLOY annunciation	On – Checked
• Reverser lever	As required
Use of the thrust reverser is authorized until the airplane comes to a complete standstill.	

1.7 Meteorological Information

Prior to the flight the crew was provided with the Terminal Area Forecast (TAF) for Wittmund (ETNT) military aerodrome, located about 50 km northeast of Emden. It contained the following information:

Wind 210°/25 kt, gusts up to 45 kt, visibility more than 10 km, scattered cloud (SCT) at 700 ft, broken cloud (BKN) at 3,000 ft; temporarily between 10:00 and 18:00, Wind 210°/25 kt, gusts up to 50 kt, visibility 7,000 m, light rain, broken cloud (BKN) at 700 ft and overcast (OVC) at 1,500 ft.

Via the Internet, the flight crew also obtained information about the weather at the city of Emden, which was as follows: morning temperature 9°C, midday 10°C, wind southwest at 41 km/h, gusts to 72 km/h; 95% risk of precipitation estimated 5 to 15 litres per square metre; humidity 87%.

The official DWD German Meteorological Service weather forecast stated:

1. Aviation Meteorological Forecasts

The GAMET issued for the Bremen FIR 0900 on 18.11.2009 valid for the period 0900 UTC to 1500 UTC forecast: wind in the northwest part of the area 30 to 35 kt; 4,000 m horizontal surface visibility, with rain or drizzle; significant clouds 600 ft AGL to 800 ft AGL expected for the period 0900 UTC 1200 UTC.

The GAMET forecast moderate turbulence below 3,000 ft AGL, with strong turbulence near the coast. The Aviation Meteorological Forecast issued at 0600 UTC and valid for the period 1200 UTC to 1800 UTC for the northern area predicted gusts up to 55 kt. For the period 0800 UTC to 1000 UTC the GAFOR-Area 05 (northwest Lower Saxony) was classified as DELTA 1 ('difficult'), and commensurate with horizontal surface visibility of 8 km and a cloud base between 1,000 ft AGL and 2,000 ft AGL.

The classification for the period 1000 UTC to 1200 UTC was DELTA 4. This was commensurate with horizontal surface visibility of from 5 km to 8 km and/or a cloud base between 1,000 ft AGL and 2 000 ft AGL. No SIGMET (Significant Meteorological Weather Warning) was issued for this period. The Airfield Weather Warning for Emden and the die AIRMET for GAFOR area 05 (northwest Lower Saxony) issued at 0757 UTC, were valid from 0830 UTC to 1800 UTC. They warned of strong wind from the southwest with gusts of from 40 to 45 knots, up to 50 knots near the coast.

2. The General Weather Situation

On 18.11.09 a depression over the British Isles developed into a small but powerful hurricane-force depression and shifted over the North Sea towards Jütland. This depression brought wide-ranging hurricane-like gusts to the North Sea. A wide area of rain was coupled with the warm front, which reached Emden during the course of the morning.

3. The weather, visibility and cloud development in the flight region

At 1000 UTC the Emden (EDWE) weather station reported wind from 200° at an average speed of 19 knots and gusting 33 kt; at 1100 UTC the wind was from 200° at an average wind speed of 21 kt, gusting 35 kt.

The data indicates there was probably moderate turbulence in the lower air layers up to 3,000 ft AGL.

1.8 Aids to Navigation

A non-directional beacon (NDB) was available for instrument approaches to Runway 25.

1.9 Communications

Communications were conducted with the respective air traffic controllers in the English language. Communications were recorded, and the recordings were available for the investigation.

1.10 Aerodrome Information

Emden civil aerodrome (EDWE) is 2 ft above mean sea level and has a single hard runway oriented 07/25. The asphalt runway is 1,300 m long and 30 m wide. The threshold to Runway 25 is displaced by 100 m, leaving a usable runway length of 1200 m.

Both landing directions have an NDB approach. At the time of the accident Runway 25 was in use and in full and unrestricted service, as was the NDB.

This civil aerodrome is approved for aircraft up to a gross weight of 14,000 kg. An exemption for higher weight take-off and landing has been issued for the Falcon 900EX by the Lower Saxony Oldenburg Regional Transport Planning Authority. The

exemption was valid for the period to 30.06.2010 and included the following limitation:

- Flights based upon this approval may only be conducted if they conform to the limitations contained in the Airplane Flight Manual (AFM).
- Adequate fire and rescue services are assured.
- Actual take-off weight must not exceed 14,000 kg.

The fire and rescue service provision at Emden civil aerodrome normally meets the requirements of ICAO Category 3, but is enhanced to Category 4 on request by the provision of a special fire fighting vehicle by the city of Emden. A suitable vehicle was on hand from 10:45 to satisfy this requirement.

1.11 Flight Recorders

1.11.1 Flight Data Recorder

The aircraft was equipped with Solid State Flight Data Recorder (SSFDR), P/N 980-4700-025 manufactured by Allied Signal, and records 90 parameters. For this investigation, data was logged and available for the previous twelve flights.

1.11.2 Cockpit Voice Recorder

The aircraft was fitted with a Solid State Cockpit Voice Recorder (SSCVR), P/N 980-6022-011 made by Allied Signal. The SSCVR had a recording endurance of two hours. The recording covered the entire period in question, and was available for this investigation.

1.12 Wreckage and Impact Information

Having overrun the end of Runway 25, the Falcon 900EX came to a halt with the nose gear on the grass. The fuselage nose was about 8 m beyond the runway end. About 2.70 m of the front fuselage rested on the grass on the collapsed nose gear. Both main landing gears were still on the runway, the left gear about 1.50 metres in front of the runway end. The fuselage longitudinal axis was directed about 12° to the right of the runway heading and located to the right of the runway centreline.

The end of Runway 25 is denoted by marker lights, plus a line of approach lights to Runway 07 which are located about 2.40 m away from the asphalt surface. Together with its concrete plinth, one of these lamps had been pushed backwards and was found behind the cabin door after the aircraft came to rest. The lamp remained operable.



Final position of the aircraft

Photo: Emden Flight Information Service

The nose gear under the aircraft had broken off, and bore traces of an impact. The nose gear doors were partly torn off or badly damaged. The fuselage belly had been pushed in behind the nose gear shaft, and had horizontal and vertical dents reaching almost to the cockpit windows on both sides. The underlying airframe structure was partly damaged.

After impact with the concrete plinth and fall of the fuselage nose to the ground, the aircraft was damaged mainly on the lower fuselage from frames 0 to 8.

Inspection revealed the following damage:

- Frame A bent and broken on the lower side; nose profile deformed, no longer fitting Frame 0
- Frame 0 bent at the attachment area; radome closure bent; attachment points and closing pin broken on lower side.
- TAT sensor defective.

- Strong deformation in lower area between Frames 2 and 4.
- Nose gear attachment points broken.
- Lower part of Frame 4 broken.
- The entire structure around the nose gear must be examined and surveyed.
- Nose gear doors torn off.
- Transverse members bent Frames 4 to 7.
- Floor structure bent or broken between Frames 4 to 8.



Damage to nose gear and front fuselage



Photos: BFU



Runway lighting

Photo: Emden Flight Information Service



Runway lighting on concrete plinths

Photo: BFU

1.13 Medical and Pathological Information

Not applicable.

1.14 Fire

There was no fire.

1.15 Survival Aspects

The Falcon 900EX has a single passenger access door in the front left fuselage. The door incorporates a set of stairs that deploy when the door is open. There is also an emergency exit located in the fuselage wall over the right wing.

A third crew seat is located directly behind the co-pilot's seat in the right hand side of the fuselage and faces at right angles to the direction of flight. The flight attendant occupied this seat during the approach. There is no partition door between the cabin and cockpit. The seated third crew member has a view both into the cockpit and the passenger cabin.

When the aircraft had come to rest, it was not possible to open the door to its fullest extent. It was half-opened and then rested upon the ground in an almost horizontal position. In this position, the stairs were presented as a line of triangles with the apex directed upwards.



Post-accident position of the passenger door

Photo: BFU

1.16 Tests and Research

None

1.17 Organisational and Management Information

None

1.18 Supplementary Information

Extract from the "Standing instructions for Flight Information Service Agents at airfields without Air Traffic Control in Lower Saxony "

Item 19.2 Landings

[...]The pilot of an approaching aircraft should be advised by suitable means (e.g. radio) of the prevailing current conditions, so that he can make a decision about the intended landing at his own discretion. A record is to be made of the advice given.

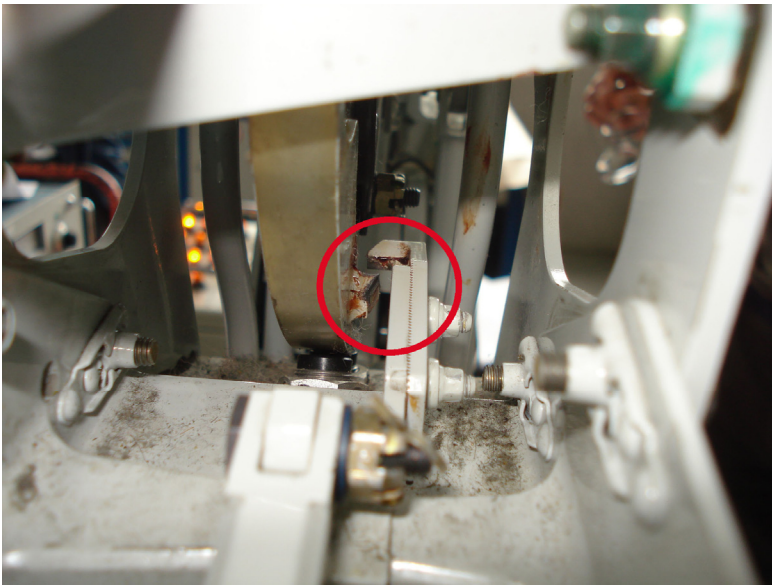
1.19 Useful or Effective Investigation Techniques

The Throttle Control Unit (TCU) has a reverse thrust lever which is retained in the idle position by a mechanical lock. It remains in this position until the reverse thrust doors in the engine cowling are fully deployed. Only then can the lever be operated to provide full power reverse thrust.

The TCU was tested a number of times, first as installed on the aircraft and then on a laboratory test stand. In each case there was no difficulty in effecting full and immediate movement of the reverse thrust lever to the fully deployed position.

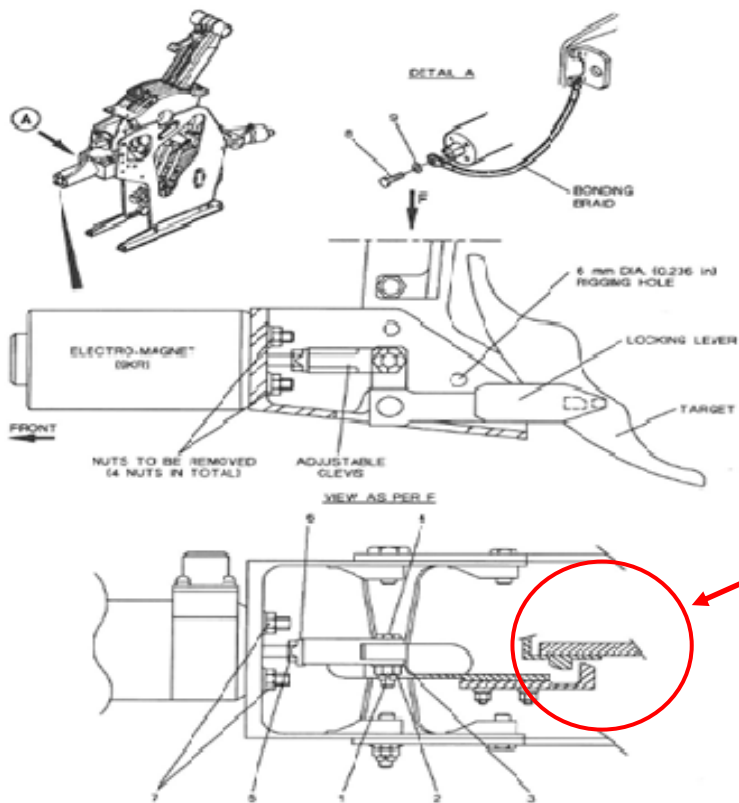
During both series of investigations, it was evident that the first mechanical lock did not operate correctly, and it bore clear traces of a high degree of mechanical wear. When on the laboratory test stand, it was repeatedly possible to immediately and fully advance the reverse thrust lever by the application of a force of 500 gF (as measured with a dynamometer).

New measurements were made after the locking mechanism had been correctly adjusted, following which the lock remained effective when subjected to a force of more than 11.5 kgF.



Mechanical lock on the TCU

Photo: BEA



Mechanical Lock

Throttle Control Unit

Source: Dassault

2. Analysis

The flight from Braunschweig to Emden was done as a regular non-public company flight.

This accident investigation focuses upon the reasons why the aircraft overran the runway, and looks at both operational and technical aspects.

The investigation showed there was no single factor that caused the aircraft to over-run the runway; rather there were several factors which together led to this accident.

2.1 Operational Aspects and History of the Flight

Local Conditions

Prior to the flight the crew had adequate information. Both pilots had previously flown to Emden airfield and were familiar with the local infrastructure and the relatively short runway. There were no local limitations in force and the full 1200 metres of runway were available for the landing.

There was sufficient time available prior to the flight for preparation, evaluation of the weather forecast, consideration of the infrastructure conditions at the destination, and incorporation of the data into the necessary pre-flight calculations.

Meteorological Information

Sufficient official weather briefing information was available on the day in question.

Because the only weather forecast for Emden civil aerodrome was via an Internet Portal, the crew obtained the TAF and METAR for Wittmund Military (ETNT). Given the short distance between Emden and Wittmund and using the SIGMET chart issued by WAFC in London, the assumption could be made that the weather at Emden civil aerodrome would be very similar to that at Wittmund Military.

During the flight, the crew prematurely established contact with Bremen Radar through whom they obtained the latest weather for EDWE.

The weather report for ETNT accurately reported the wind at 25 kt. However, during the approach and landing the wind gusts were below the forecast value of 45 kt, and the Emden Flight Information Safety agent did not subsequently report such gusts.

The weather reports obtained for the Emden region via the Internet Portal agreed with the forecast for Wittmund Military (ETNT), both of which forecast light rain.

The weather information available was both sufficient and accurate for the flight in question and did not flag up a need for any limitations. The weather information implied that the landing would be gusty and the runway probably wet. Further information regarding the runway condition have not been given during the flight.

Brakes

The brake selector switch was in Position 1 (normal braking with antiskid system) as required by the *Before Take Off* checklist, and remained in this position for landing. The CVR recording confirms the crew had checked the switch position.

When reading the *Final Check List*, both the First Hydraulic System and the Anti Skid System were checked; the crew subsequently stated the indications had been normal with no warnings. The CVR recordings confirm that the crew had worked through the checklists; the DFDR Flight Data Recorder confirmed there had been no hydraulic or brake system warnings. Given these conditions, the crew could fairly assume that the brake system would work normal after landing.

Approach and Landing

The crew stated that the flight en-route and approach were stable right until touchdown. This was confirmed by the DFDR trace, which showed no evidence of deviations or irregularities. The cockpit workload was light until shortly prior to touchdown; very good use was made by the crew of Crew Resource Management (CRM) and Multi Crew Concept (MCC) procedures. The crew selected an NDB approach – the only available IFR approach procedure – which was correct under the prevailing weather conditions.

The landing speed V_{ref} was calculated using the Performance Manual for the F900EX for a weight of approx. 14,420 kg at 116 kt. Based on this, the actual landing distance was 745 m for a dry runway. Given the anticipated gusts, the crew correctly increased the V_{ref} speed by 12 kt.

The crew could have seen that the runway was wet and had some large puddles in the final quarter – as described by witnesses – because they themselves subsequently confirmed they had the runway in sight at a height of about 1,700 ft during the NDB approach (about 5 NM from the airfield). However, the cockpit voice record-

ing bore no mention of the runway condition and according to the crew's statement was also not recognized during the approach.

The aircraft touched down about 214 m after the runway threshold. Given that the runway is short and the calculated performance data, even under ideal conditions this was very late to brake the aircraft to a full stop on the runway.

Before touch down, neither pilot called for or initiated a go-around.

After touchdown, as required the Pilot Monitoring (PM) deployed the airbrakes. Simultaneously, the Pilot Flying (PF) returned the Engines 1 and 3 thrust levers to idle. The reverse thrust unit on Engine 2 was immediately advanced from approx. 51% N1 (thrust setting for landing) and reached full power within two seconds.

Due to the short runway the thrust reverser had to be selected as early as possible which was performed by the PF immediately after touchdown. Since the mechanical stop of the reverser lever did not work properly it was possible to select the lever directly to full reverse. This resulted from the combination of the defective thrust reverser lever and the non-adherence to the checklist which requires to check the indications "TRANSIT" and "DEPLOYED" before using the reverser without restrictions.

The 'Go-Around' call came from the PF about eight seconds after touchdown. However, given the short runway, this call came too late for a safe go-around. At this time there was about 550 m runway remaining; the flaps were set to 40° and the reverse thrust was delivering full power.

This was immediately recognised by both the PF and PM and the go-around was abandoned, with continued braking action. This was in accordance with the Operating Manual, Normal Procedures, under the heading 'Thrust Reverser Operation'.

The reverse thrust was deselected about 14 s. after touchdown. Although the use of reverse thrust does not form part of the performance calculations for certification and flight planning, it is nevertheless a major factor when bringing the aircraft to a halt on a wet runway. There was no requirement to terminate use of the reverse thrust; the Aircraft Flight Manual states that the use of reverse thrust may continue until the aircraft has come to a complete stop, and should therefore be used particularly on short wet runways.

However, given the faulty operation of the reverse thrust mechanism, the reverse thrust was not totally effective. It failed to achieve the deceleration desired and normally found with combined use of reverse thrust and wheel brakes. For this reason, the crew was correct in terminating the use of reverse thrust against the guidance contained in the AFM; in this case, it increased the braking effect.

When the crew judged it was no longer possible to come to a full stop on the runway, the captain steered the aircraft towards the right in an effort to avoid a collision with runway lighting (seven lamps on concrete plinths). Nevertheless, the nose gear collided with the runway lighting outer right concrete plinth, bringing the aircraft to a stop. Although the nose gear broke off, this manoeuvre prevented a collision of the main landing gear and wings with the lamps and concrete plinths; this could possibly have broken off the main landing gear and ruptured the fuel tanks.

Speed/Landing Distance

The touchdown speed V_{ref} was calculated based upon the AFM figures for the F900EX at a weight of approx. 14,420 kg at 116 kt. The resulting landing distance required was 745 m for a dry runway. Given the weather forecast, the assumption had to be made that the runway would be wet for the landing; the Performance Manual stated that under these conditions a further 15% runway distance was required. With this addition, the corrected landing distance was 857 m.

Given the wind gusts forecast, the crew increased the V_{ref} by 12 kt, in-line with the requirements of *OM-Normal Procedures*. The Performance Manual states that the landing distance increases by 15% for each additional 10 kt speed over the threshold. Therefore based on a calculated landing distance of 745 m, the aircraft would require 857 m to stop on a dry runway.

If the higher speed and wet runway are factored into the calculation, the landing distance required is 986 m. The cockpit voice recording during the approach had no indication that the wet runway and increased V_{ref} had been taken into account. According to the crew these factors have been discussed during the briefing before the flight and they calculated with a wet runway solely, because the rain showers – as shown on the radar picture of the weather briefing – moved and cleared to the north-east as expected.

The landing weight exceeded the maximum permissible weight for the airport by about 420 kg, even this was within the exemption of the authority which showed only a limited weight for take-off. Landing with a weight of 14,000 kg would have resulted in an actual landing distance of about 725 m on a dry runway and with the applied factors of about 958 m. This does not take into account the defective thrust reverser.

Touch Down Point

As seen by the BFU, the late touchdown was due to several factors:

- Given the actual landing weight, the approach speed was too high. At 50 ft above ground the CAS was about 132 kt; an additional 4 kt which had to be reduced for the landing.
- The thrust levers were not reduced to idle on descending through 50 ft, in order to reduce the touchdown speed. When passing through 50 ft above ground, the data indicated approx. 61% N1, and about 57% N1 at touchdown.
- The crosswind was strong with approx. 15 kt.

2.2 Technical Aspects

Reverse Thrust

The reverse thrust was activated immediately following touchdown and developed full power after about 4.5 s. However, according to the DFDR trace at no time did it reach the fully deployed condition, in spite of the fact that the crew had selected full power with the thrust reverser lever.

A Master Warning was issued about 6 s after operation of the reverse thrust. Other than the long 'in transit' duration of the reverse thrust operation and its failure to reach the 'deployed' condition, the DFDR record had no indication of any other failure. The condition 'not deployed' and selection of reverse thrust further than 'idle' resulted in the Master Warning.

The Master Warning was therefore clearly due to faulty operation of the reverse thrust, because all other systems operated correctly. The time delay results from the way the system operates. The crew were aware of the Master Warning, but were unable to identify the reason, resulting from the high workload during the rollout along the runway.

During the landing the thrust reverser doors remained in a partway position between 'stowed' and 'deployed'. Since the engine was already delivering high power the doors were unable to attain the deployed condition. The Master Warning was therefore due to the condition: 'reverser out, doors not deployed'.

During that period when the crew believed it had selected reverse thrust, part of the thrust was directed forwards as braking action, and the remainder was directed rearwards to advance the aircraft in the normal way. During the investigation it was not possible to determine the strength of the respective thrust component in each direction.

The DFDR recording showed that, following de-selection of reverse thrust, the aircraft clearly decelerated more rapidly. The crew also stated that they had noticed virtually no deceleration following touchdown, and their statement is supported by the DFDR data. During the phase in which reverse thrust was selected, the deceleration fluctuated about the value of -0.16 g. These values had been reached about 3 s after touchdown and remained at this average value for another about 11 s. After de-selection of reverse thrust, the deceleration increased to about -0.31 g within 4 s and remained at this average value until exiting the runway end. The poor deceleration is therefore attributed to the reverser because the runway conditions remained mostly constant and only on the last 200 m larger puddles have been existent. According to calculations of the BFU with an immediate increased deceleration to about -0.31 g after about 6 s the aircraft would have travelled about 231 m less and an overrun could have been prevented. With a deceleration force of only about -0.21 g continuously the aircraft could have been stopped on the runway.

Investigation and tests have confirmed that a force of only 500 gF was required to overcome the reverse thrust mechanical lock and therefore enabling the thrust to be advanced to full power before the thrust doors were fully opened.

Traces of abrasion on the mechanical lock have been found. A third-party exposure could not be confirmed while investigating the lock with a microscope. The abrasion traces showed that the condition of the lock existed for a longer time and was already overridden more often.

Damage to Aircraft

The main damage to the aircraft was due to the fact that the nose gear impacted with the runway lamp concrete plinth and then broke off. Further damage resulted to the airframe cell and structure when the fuselage then dropped onto the broken nose gear, which lay under the fuselage in a longitudinal position.

The runway lighting concrete plinth was a major cause of damage. The plinths were not countersunk into the earth, but projected about 15 cm above the surface. Thus

the design break points on the lamps were without purpose and completely ineffective.

If the aircraft had only collided with a lamp, this would have bent at the design break point and avoided serious damage to the aircraft. If the lamps had been correctly installed, they would have bent upon impact, the electrical supply would have switched off, and there would have been less danger from the possibility of setting light to fuel escaping from possibly ruptured tanks.

Survival Aspects

The passengers quickly left the aircraft through the normal access door – similar to an evacuation, which had not been expressly ordered – and in the absence of fire was a suitable procedure.

However, the half-open position of the access door presented the risk that there was no horizontal surface for a safe footing. A person stumbling or falling during egress or evacuation could block the exit for persons behind, and add to the possible danger.

If the occupants are to evacuate and if there has been no fire on the right hand side of the aircraft, evacuation is preferred via the emergency exit over the right wing, because this route is unobstructed.

3. Conclusions

3.1 Findings

The crew was properly licensed and qualified for the flight. The captain had ample experience from many years of flight duty and his additional qualification as a Type Rating Instructor and Examiner (TRI/TRE). The co-pilot showed commensurate experience.

The Flight Attendant and Emden Flight Information Service agent were properly qualified for their respective tasks.

On the day in question Emden civil aerodrome was available for full use and without limitations. The full runway length was available and the landing exemption was in force and valid. The landing exemption limitations were respected in full.

The DFDR recording had a number of parameters whose evaluation confirmed faulty operation of the reverse thrust system. This data made a major contribution in determining the causes of the accident.

The cockpit voice recording revealed the crew workload, particularly in the short final phase of the flight and the post-landing rollout to full stop. The crew communications and decisions were understandable, and agreed with their post-flight statements.

The approach was stabilised and in accordance with the objectives laid out in the manufacturer's Operating Manual, Procedures.

Given the forecast presence of gusts, the increase in approach speed met the requirements of the AFM.

The longer landing distance that would result from the increase in the approach speed, was not taken into account.

Given the short runway length, the touchdown was made too far behind the threshold.

The thrust levers were reduced to 'idle' too late.

The runway condition was such it would have been possible to bring the aircraft to a full stop following touchdown.

The defective reverse thrust mechanism negated some of the braking effect.

Serious damage to the aircraft resulted from impact with a protruding concrete plinth that supported a lamp.

Following impact, the lamps should have switched off at once to minimise the threat of igniting any fuel that might have emerged from ruptured tanks.

3.2 Causes

The following causal factors have been identified:

- The extended landing distance due to the increased approach speed, was not taken into account.
- The aircraft touched down too late on the runway.
- Consideration of a go-around came too late for action.
- The go-around was not carried out.

- The engine thrust was reduced too late.
- A faulty reverse thrust mechanism partly negated the effect of wheel brake operation, thereby extending the landing distance.

4. Safety Recommendations

None.

Investigator-in-charge: Andreas Bresky

Aided by: U. Berndt, D. Ritschel, H. W. Hempelmann,
 D. Nehmsch

Investigators on-site: A. Bresky, U. Berndt

5. Appendices

Appendix 1: Extract from the Flight data Recorder

