AIRCRAFT INVESTIGATION REPORT ZKM KHAIA 001/R

Republika e Kosovës
Republika Kosova-Republic of Kosovo
Qeveria –Vlada-Government
Zyra e Kryeministrit – Ured Premijera –Office of the Prime Minister

Komisioni për Hetimin e Aksidenteve dhe Incidenteve Aeronautike /Vazduhoplovna Komisija za Istraživanje Nesreća i Incidenata/Aeronautical Accidents and Incidents Investigation Commission

Report on Serious Incident of aircraft Boeing B737-800, TC-JFY at the International Airport of Pristina "Adem Jashari", on 2 May 2016

ENGLISH LANGUAGE VERSION

PRISTINA: JULY 2018

Aeronautical Accident and Incident Investigation Commission is established on the basis of the Law No. 03/L- 051 on Civil Aviation of Republic of Kosovo. The Commission shall be responsible to investigate aviation accidents and incidents within Kosovo territory or which involve airplanes registered in Kosovo, wherever they may be. According to regulation (AAIIC/OPM) NO.01/2017 on the investigation and prevention of accidents and incidents in civil aviation and to international Aviation regulations, more precisely to Annex 13 of The Convention of International Civil Aviation, if the accidents or incidents nevertheless occur, a thorough investigation into the cause of the problem, irrespective of who is to blame for it, may help to prevent similar problems from occurring in the future. It is important to ensure that the investigation is carried independently and in full coordination between the parties involved. The Commission shall be authorized to ask from any public authority of Kosovo and natural person or organization in Kosovo to provide the required support to them for the performance of a certain investigation as defined by the Law on Civil Aviation or an investigation deriving from an international agreement or by an international aviation organization.

If there are discrepancies between language versions, priority will be given to the **ENGLISH LANGUAGE VERSION** in accordance with international rules on aviation safety investigation, more precisely to Annex 13 of The Convention of International Civil Aviation

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GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

AAIIC	Aeronautical Accident and Incident Investigations Commission
ATC	Air Traffic Control
BFU	Bundesstelle für Flugunfalluntersuchung (German Federal Bureau of Aircraft Accident Investigation)
CAA	*Civil Aviation Authority*
CVR	Cockpit Data Recorder
FDR	flight data recorder
PIC	Pilot in Command
PF	Pilot Flying
PM	Pilot Monitoring
CO	co-pilot
CPL (A)	Commercial Pilot's License
FH	flight hours
h	hours
METAR	Meteorological Aviation Weather Report
ATIS	Automatic Terminal Information Service
ft	feet
ICAO	International Civil Aviation Organization
kg	kilogramme
RA	Radio Altimeter
V/S	Vertical Speed
AAL	altitude above Aerodrome level
MCP	Mode Control Panel
FPA	flight path angle
MDA	minimum descent altitude
CRM	Crew resource management
L/H or LH	Left Hand
R/H or RH	Right Hand
m	meter
ºC	Degrees Celcius
PIA	Pristina International Airport "Adem Jashari"
QNH	pressure setting to indicate elevation above mean sea level
R/H or RH	Right Hand
UTC	Co-ordinated Universal Time (the contemporary equivalent of GMT)
°F	Fahrenheit (1 ° F equal to -17.2222 ° C)

Aeronautical Accidents and Incidents Investigation Commission

Investigation Report no:	**ZKM KHAIA 001 / R**
Type of Occurrence:	Serious Incident
Date:	2 May 2016
Location:	Pristina International Airport Adem Jashari
Aircraft:	Fixed Wing
Manufacturer / Model:	The Boeing Company/B737 - 800
Registration:	TC-JFY
Injuries to Persons:	No injuries
Damage:	Minor damage to Aircraft
Other Damage:	None

1. Factual Information

On 2. May 2016 at 19:33[1] the aircraft veered left off the operating area after landing on runway 35 at Pristina International Airport “Adem Jashari”. The aircraft came to a stop in the grass next to the runway. All crew members and passengers onboard remained uninjured, except for six passengers, who asked for medical assistance due to disturbance and fear.

1.1 History of the Flight

At 1809 h on 2 May 2016 the Boeing B737-800 took off from Istanbul Airport, Turkey. On board of the aircraft were 6 crew members and 151 passengers. The Pilot in Command (PIC) was Pilot Flying (PF) and the co-pilot Pilot Monitoring (PM). The approach was conducted to runway 35 via the VOR / DME P (non-precision approach).

According to the tower recordings, at 1923 h the crew reported to Pristina Radar that they were established on the localizer for runway 35. Pristina Radar asked the crew to change frequency to Pristina Tower. The copilot contacted the tower and shortly thereafter received the landing clearance: “[…] THY97A Pristina Tower good day, wind 150 degrees 06 knots, runway wet, cleared to land runway 35.” At 19:29 h the co-pilot asked the tower controller for the latest wind information. The tower controller answered: “[…] Wind one five zero degrees, zero seven knots.” There was no briefing heard on the Cockpit Voice Recorder (CVR), were the pilots discussed about the tailwind component during landing. The flight crew conducted the approach and landed on runway 35. The aircraft touched down approximately 100 m beyond the runway 35 touchdown zone markings, which equals approximately 1 030 m beyond the runway threshold. The remaining runway length was approximately 1 500 m. During the ground roll the flight crew noticed that the aircraft did not decelerate as much as expected. After touchdown the co-pilot suggested to the pilot in command to stay on the runway. The CVR recorded at 19:32:39 h: “[…] let’s stay on the runway, stay on the runway”.

The aircraft veered left off the runway between the end of the runway and taxiway C and came to a full stop in the adjoining grass approximately 36 m left of the runway.

According to the tower recordings at approximately 19:33 h the tower controller asked the flight crew: “[…] THY97A confirm ready for backtrack, confirm able to backtrack?”

[1] All times local, unless otherwise stated

The co-pilot answered that they had veered off the runway: “[…] we are out of runway THY97A.”

1.2 Personnel Information

1.2.1 Pilot in Command

The 48-year-old co-pilot held an Air Transport Pilot License (ATPL (A)) issued in accordance with Part-FCL by the Turkish authorities. The license had been issued on 01 January 2010. Field XII of the license listed the rating for the Boeing B737 300-900 in accordance with instrument flight rules. The rating had been renewed on 28 October 2015 and was valid until 30 November 2016. He had a flying experience on Boeing 737of 8,090 h. His total flying experience was about 11,099:00 h.

The AAIIC had been provided with the class 1 medical certificate valid until 22 May 2016. The AAIIC had been provided with the class 2 medical certificate valid until 22 November 2016.

The PIC participated in a Simulator Recurrent Training (REC 2) on 27 March 2014, in which previous unstabilized approaches and runway excursion incidents were discussed in detail.

1.2.2 Co-pilot

The 30-year-old PIC held a Commercial Pilot’s License (CPL (A)) issued in accordance with Part-FCL by the Turkish authorities. The license had been issued on 23 October 2014. Field XII of the license listed the rating for the Boeing 737 300-900 in accordance with instrument flight rules. The rating had last been renewed on 11 April 2016 and was valid until 31 May 2017 . His flying experience on Boeing B737-800 was about 335 h. His total flying experience was about 615 h.

The AAIIC had been provided with the class 1 medical certificate valid until 18 February 2017. The AAIIC had been provided with the class 2 medical certificate valid until 18 February 2021.

1.2.3 Flight Crew Information

It was the first flight of the day for the entire crew. The operator provided the crew rooster of each crew member. There were no flight time limitation exceedances.

1.3 Aircraft Information

The Boeing B737 - 800 is a low-wing transport aircraft with conventional tail and equipped with two turbofan engines.

Manufacturer:	The Boeing Company
Type:	Boeing B737 - 800
Year of manufacture:	2000
Serial number:	29783
Maximum Take-Off Mass:	79 015 kg
Engines:	Two CFM 56-7B26

The aircraft had a Turkish certificate of registration and was operated by a Turkish air operator. A valid airworthiness review certificate (arc) had been provided to the AAIIC.

Weight and Balance

The aircraft weight and balance information was provided by the operator. The following values are based on the actual Loadsheet of 2 May 2016.

The calculated takeoff mass was 67 750 kg and center of gravity index for the take-off was 22.5. The estimated landing mass was 64 515 kg with a center of gravity index for landing of 23.0. The trip fuel was calculated with 3 235 kg. All values were within the allowed limitation envelope.

1.4 Meteorological Information

Pristina International Airport “Adem Jashari” (BKPR) weather observation at 17:30 UTC: wind from 080° at 9 kts, visibility at 4 000 m, rain, broken clouds at 1 000 ft, overcast at 2 500 ft, temperature 12°C, dew point 9°C, altimeter 1 006 hPa. No significant change.

For the landing the valid Meteorological Aviation Weather Report (METAR) was:

BKPR 021730Z 08009KT 4000 RA BKN010 OCV025 12/09 Q1006 NOSIG

ATIS received from the pilots according to the CVR was:

17:07:45 UTC P 1653 35 VOR/DME; wet; ba good; tL/120 birds; 020/09 Vis 10km – RA SCT 1000 11/09 Q1006

For the landing the valid wind asked by Co-pilot from the ATC according to the CVR was:

17:29:49 UTC wind 150 degrees 7 kts

The following weather shows the overall weather situation at Pristina International Airport “Adem Jashari”. It was raining before and after the landing.

Archived METAR from 2. May 2016 in the period of 16:00 to 22:00 UTC:

BKPR 021600Z 09011KT 7000 -RA SCT015 BKN030 13/09 Q1006 NOSIG

BKPR 021700Z 02009KT 8000 -RA SCT010 BKN025 11/09 Q1006 NOSIG

BKPR 021730Z 08009KT 4000 RA BKN010 OVC025 12/09 Q1006 NOSIG

BKPR 021800Z 13009KT 5000 RA BKN012 OVC025 11/08 Q1006 NOSIG

BKPR 021900Z 13008KT 9999 -RA SCT015 BKN040 10/08 Q1007 NOSIG

BKPR 022000Z 12011KT 9999 -RA SCT013 BKN040 10/07 Q1006 NOSIG

BKPR 022100Z 10007KT 9999 -RA SCT013 BKN035 10/07 Q1006 NOSIG

BKPR 022200Z 10006KT 9999 SCT018 BKN050 10/06 Q1006 NOSIG

The EURO Significant Weather Chart (Sig WX) of 12:00 UTC was valid during the time of the incident. In the area of Pristina International Airport “Adem Jashari” there were clouds with isolated embedded cumulonimbus forecast with tops up to FL 300.

1.5 Aids to Navigation

For runway 35 a Non-Precision Approach - VOR/DME P was available as depicted in the Aeronautical Information Publication (AIP), 24 July 2014. The landing system accuracy was last checked on 2 April 2015. There were no irregularities.

1.6 Communications

Most of the crew conversations on the Cockpit Voice Recorder (CVR) could be easily understood. The flight crew completed all checklists in English language. Normal conversation between the two pilots was conducted in Turkish language. Communications between pilots and the Cabin Chief were conducted in Turkish language. The BFU/Germany prepared a transcript of the English part of the CVR recording. With help of the official airline representative the spoken phrases were translated into English.

Communications between pilots and Air Traffic Control (ATC) in Pristina were conducted in English language.

1.7 Aerodrome Information

Pristina International Airport “Adem Jashari” (BKPR) is located 15 km south-west of Pristina city and 3 km south of Slatina. The airport has 1 runway with the orientation 176°/356°.

Runway designator:	17 / 35
Runway dimension:	2 500 m x 45 m
Runway surface:	Asphalt
Aerodrome reference code:	4C

Pavement surface and bearing strength is asphalt PCN 100/F/B/X/T. RW17 slope 0.04 % down. Runway 17 has precision approach, category II (CATII). Runway 35 has non - precision approach. Physical characteristics of runway are in compliance with the standards of ICAO Annex 14. The NOTAMS showed no limitations for the conducted approach.

Declared Distances:

Runway 17 and 35:

TORA (Take-off Run Available):	2 501 m
TODA (Take-off Distance Available):	2 501 m
ASDA (Accelerated Stop Distance Available):	2 501 m
LDA (Landing Distance Available):	2 501 m

The CAA of Republic of Kosovo has provided to AAIIC Certification of Airport and a document where states the Certification History of Airport and RESA.

1.7.1 Certification History of Airport

The interim aerodrome certificate was issued by the Flight Safety Division of the Icelandic Civil Aviation Administration on 1st August 2007 and it was extended on 1st January 2008.

On 1st of December 2008, the aerodrome certificate was issued by Civil Aviation Authority of Kosovo pursuant to Article 61 of the Kosovo Law 03/L-051 on Civil Aviation and Regulation 01/2008 on Aerodromes. Four amendments to the certificate has been issued due to the change of working hours (29.03.2009), upgrade of ILS category (01.11.2010), change of name (26.11.2010) and transfer to the new operator (04.04.2011).

On 8th of November 2013 PIA “Adem Jashari” has been granted a certificate, reflecting the construction of new terminal building, apron and associated infrastructure. The certificate remains in force 5 years from the date of issuance.

1.7.2 Runway End Safety Area

The End Safety Areas (RESA) was provided at each end of the runway. The dimensions of the runway end areas are 90 x 90 m. No fixed object, other than visual aids required for air navigation or those required for aircraft safety purposes and which must be sited on RESA and satisfying frangibility requirement are not located on runway end safety area. All foundation or manholes within RESA are flush with the surface and delethalised. The transversal and longitudinal slopes are within the requirements. Rescue and firefighting vehicles are provided at Pristina International Airport “Adem Jashari”.

1.8 Flight Recorders

The aircraft was equipped with a Solid-State Flight Data Recorder (SSFDR) and a Cockpit Voice Recorder (CVR).

1.8.1 FDR

Manufacturer:	Honeywell
Type:	SSFDR
Serial number:	12 754
Part Number:	980 – 4700 - 042

The recorder had no visible damage. The stored data were read out and evaluated with Insight Analysis software. On the recorder there were 26 h of flight data found including the incident occurence.

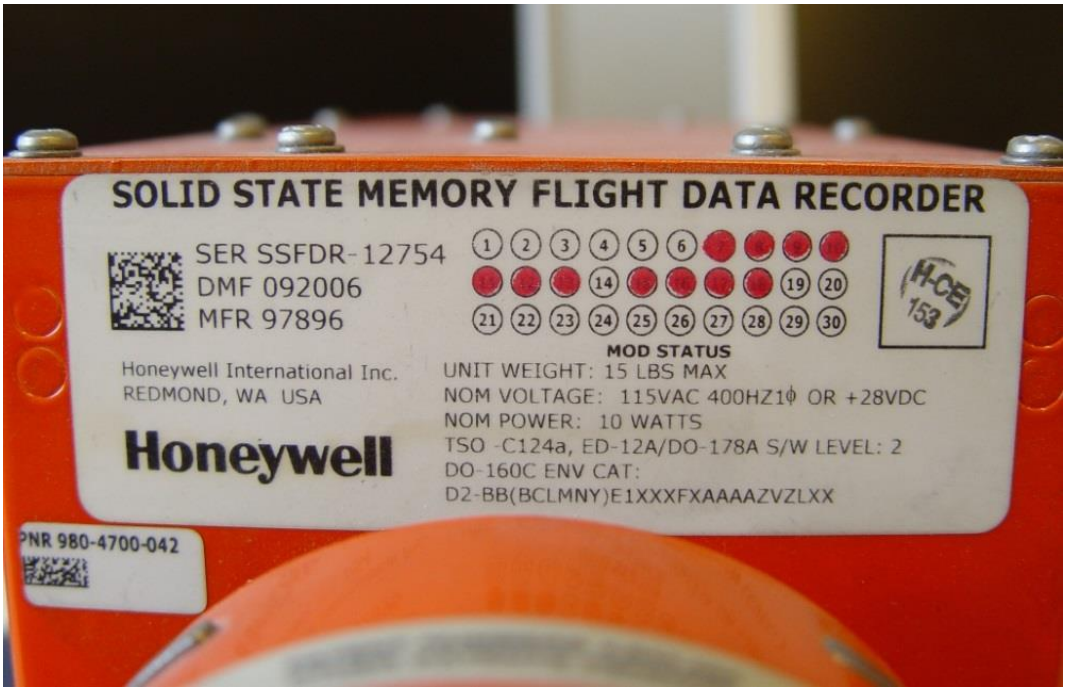


Image 1: Flight Data Recorder Source: BFU/Germany

1.8.2 CVR

Manufacturer:	AlliedSignal
Type:	SSCVR
Serial number:	2416
Part Number:	980 – 6022 - 001

The recorder had no visible damage. The stored data were read out and stored at the BFU/Germany.
The different voices PIC, co-pilot, and Cabin Chief could be understood very easily. Most of the crew conversations could be understood accurately and easily. The transcript indicates several words or phrases that were not intelligible. Any loss in the transcript can be attributed to minor technical deficiencies, temporary interruptions in the recording system or to a large number of simultaneous cockpit/radio transmissions that obscure each other.

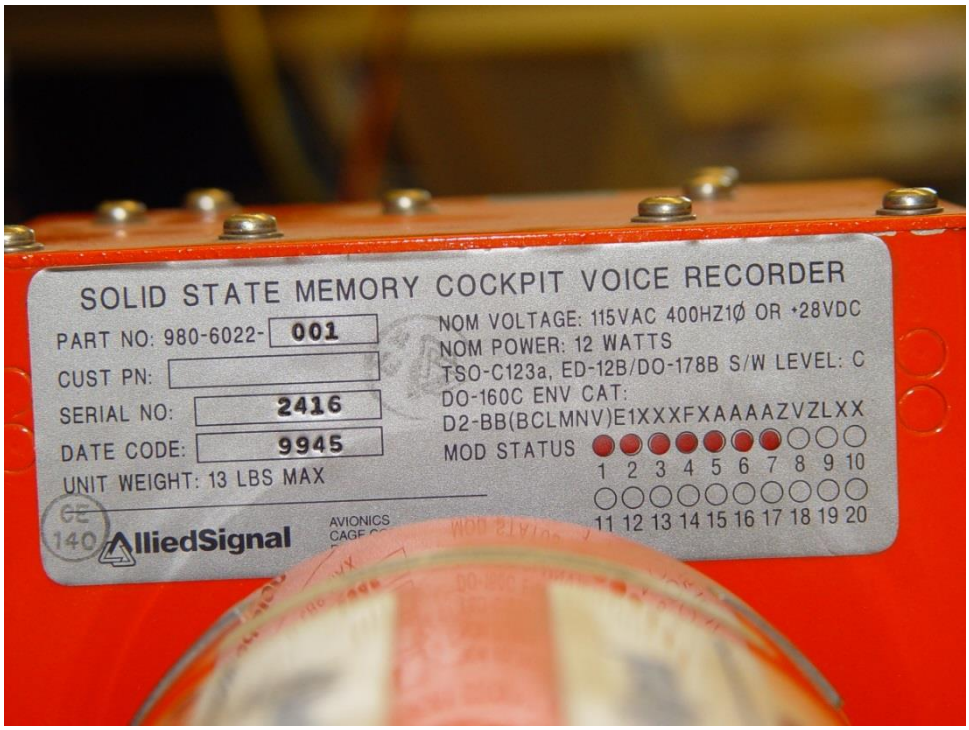


Image 2: Cockpit Voice Recorder Source: BFU/Germany

1.9 FDR Parameter description

On the following pages there are all relevant FDR parameters in relation to the approach and touch-down phase shown.

1.9.1 Approach Phase

This image shows the approach phase where the EGPWS Sink Rate Warning was activated. The vertical speed and pitch attitude was thereafter significantly reduced.

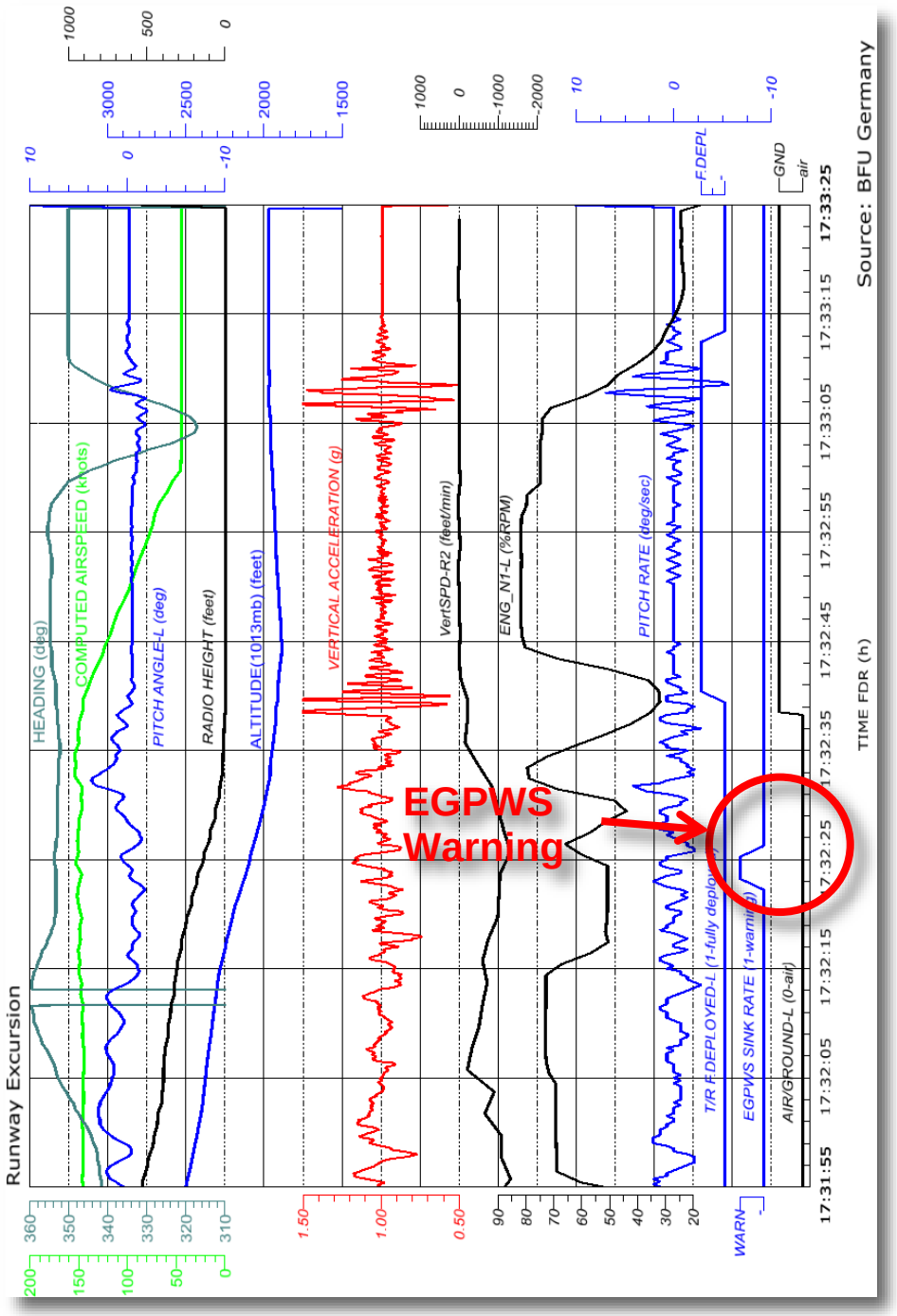


Image 3: FDR parameters of the approach phase Source: BFU/Germany

1.9.2 Approach Phase

This image depicts the touchdown phase with the wind information.

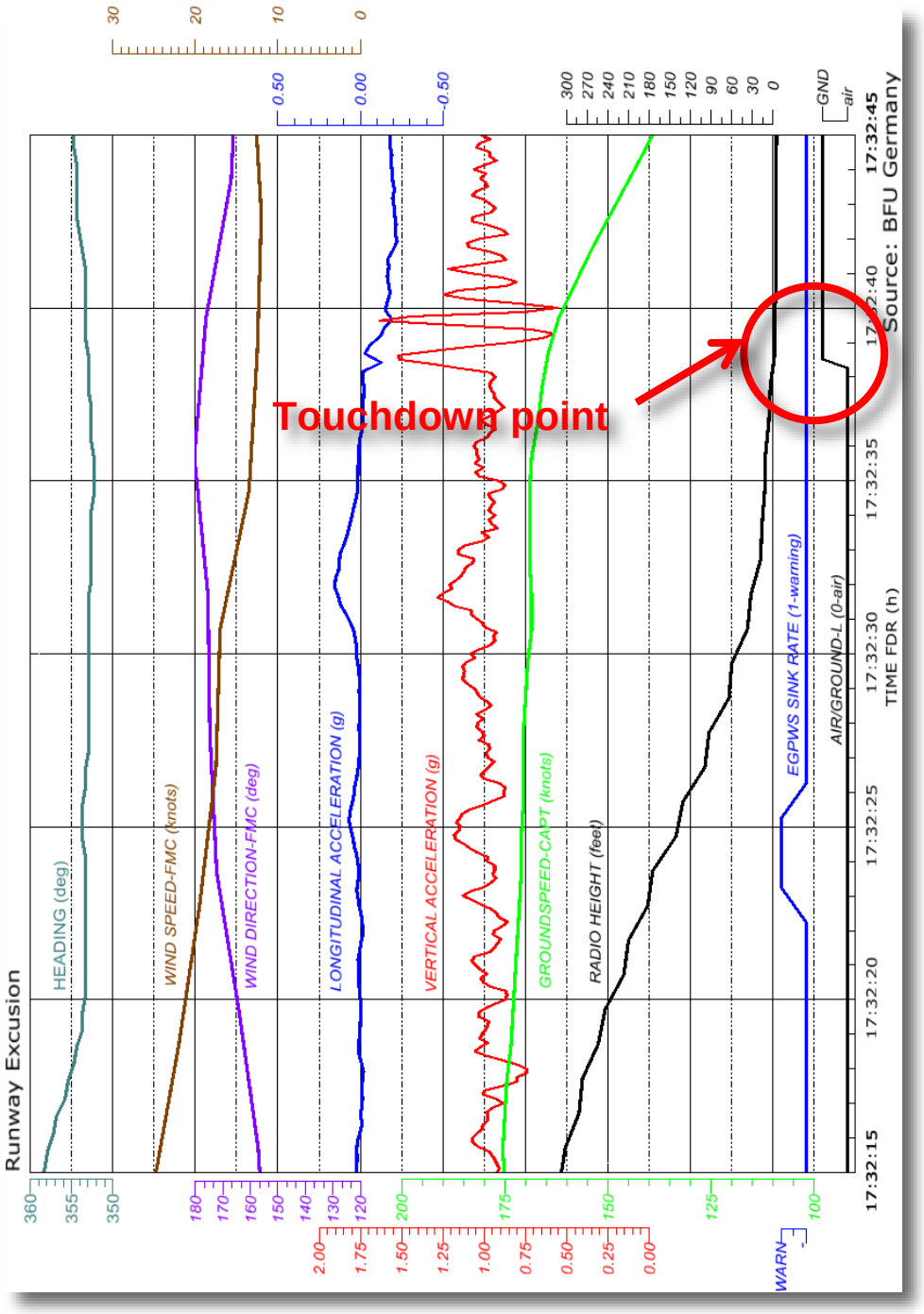


Image 4: FDR parameters of the approach phase Source: BFU/Germany

1.9.3 Touchdown Phase

This image depicts the touchdown phase with the corresponding Brake Pressure in PSI and Rudder Pedal Position in degrees.

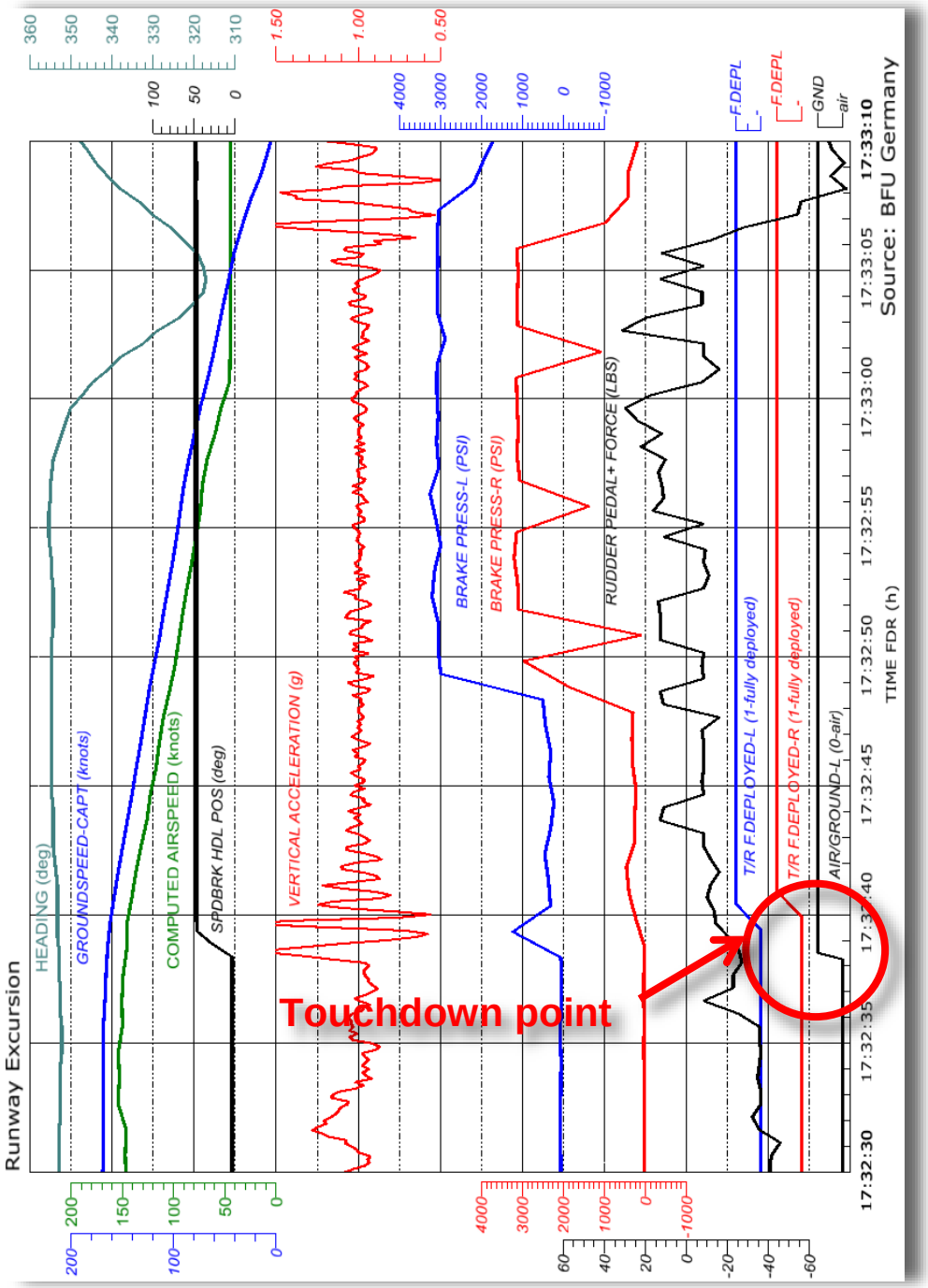


Image 5: FDR parameter of the touchdown phase Source: BFU/Germany

1.9.4 Landing Flare

The Image shows the initiated landing flare. Parameters such as Radio Height, Vertical Speed and Pitch angle were analyzed the landing flare.

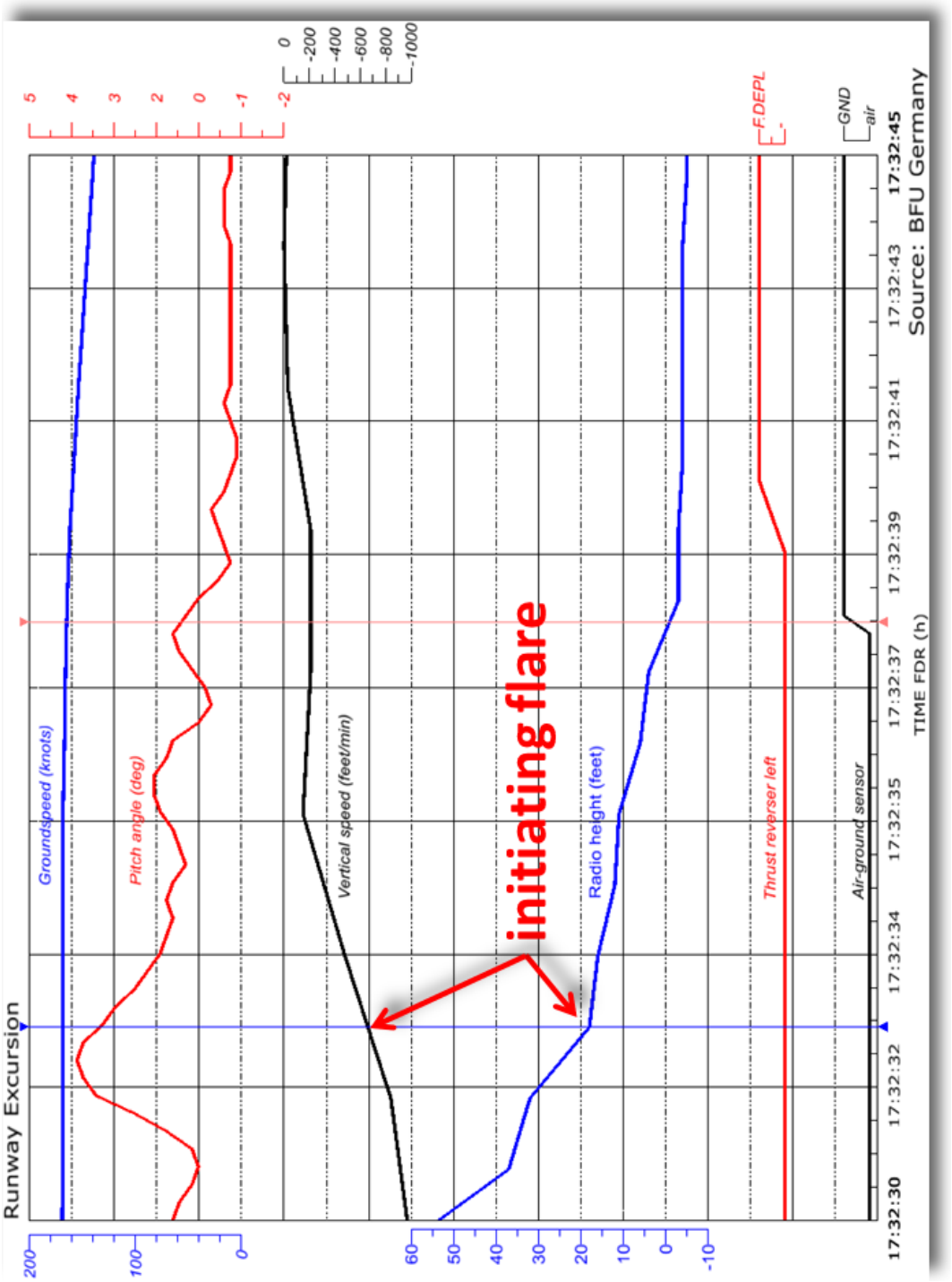


Image 6: FDR parameters of the landing flare Source: BFU/Germany

1.10 Approach Sequence

According to the FDR and CVR analysis the following items in the approach and landing sequence are pointed out:

- Descending with autopilot mode Vertical Speed (V/S) as a pitch mode
- Final Approach Fix (FAF - 15 NM from PRN VOR) was crossed with an aircraft configuration of flaps 5 and landing gear down
- As the aircraft descended through 1 000 ft AAL, the flight path angle (FPA) was 5.5° with a descent rate of approx. 1 900 ft/min
- the aircraft descended near to the MDA, V/S mode reverted to Altitude Acquire (ALT-ACQ) and the aircraft began to reduce the vertical speed
- Autopilot was disengaged at approx. 815 ft AAL
- PF reset the Flight Director at 391 ft AAL and sets the missed approach altitude 9 000 ft on the Mode Control Panel (MCP)
- PF claimed that “Sink Rate” caution sounded few times around 8 DME and corrective action was carried out
- The runway threshold was passed at approx. 80 ft higher than normal threshold crossing height.
- At 10 ft Radio Altimeter (RA) the airspeed was at approx. 150 kt Indicated Air Speed (IAS) and the engines reached the “flight-idle” position at approx. 3 ft.
- IAS at touchdown was approx. 145 kt (V_{REF}=141 kt), with ground speed of approx. 162 kt
- The aircraft initiated landing flare at approx. 20 ft AAL
- touched down occurred approx. 1 030 m beyond the runway threshold
- At touchdown vertical acceleration was approx. 1.6 g
- Autobrakes were activated immediately after touchdown
- maximum Thrust-Reverse was applied upon landing
- Manual braking was initiated at approx. 100 kt IAS at a distance of approx. 1 637 m from runway threshold
- Thrust-Reverse was canceled as the aircraft left the paved runway surface
- At the point when the aircraft left the runway, the taxi speed was approx. 50 kt

1.11 Wreckage and Impact Information

Approximately 1 030 m beyond the threshold of runway 35 wheel markings of the right main landing gear were found on the middle runway edge marking. Wheel markings were also found on taxiway C before the aircraft veered off.

Image 7: Overview where the aircraft had veered off the runway Source: Kosovo AAIIC

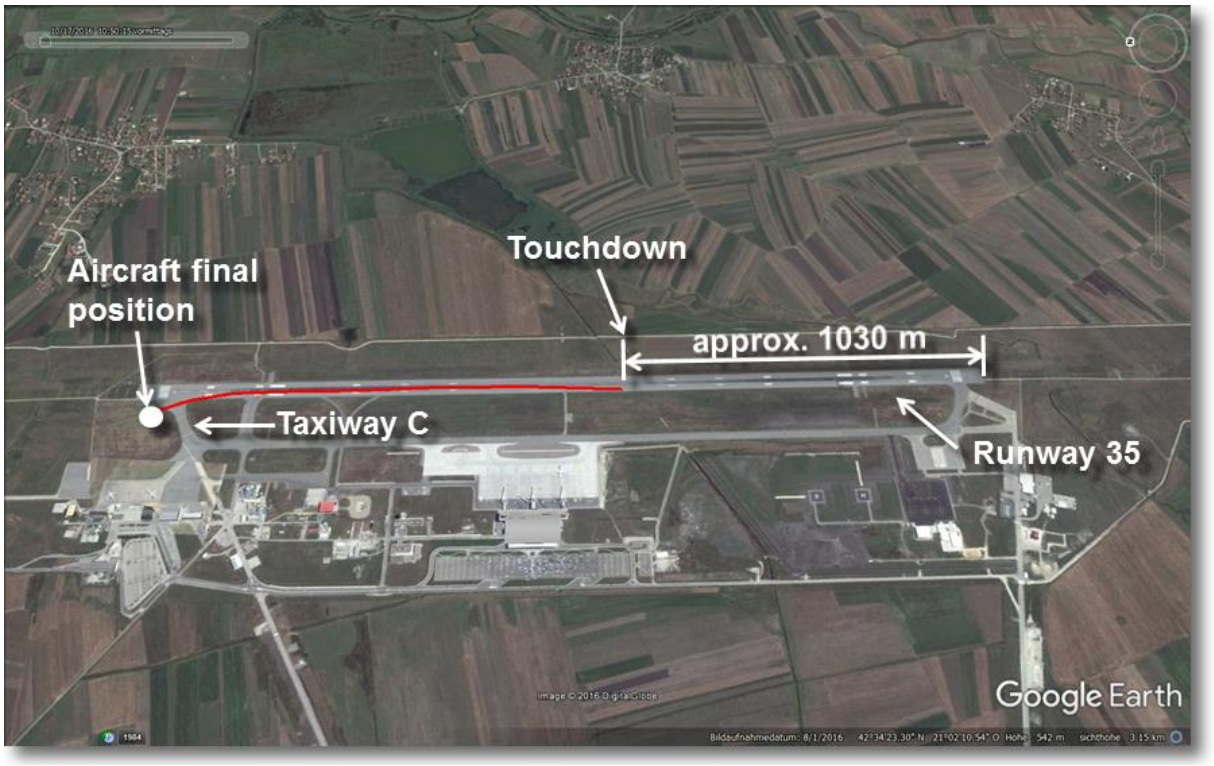
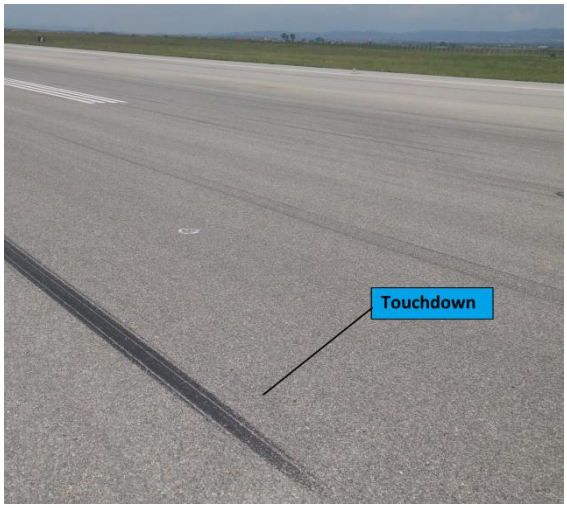


Image 8: Overview of the ground roll path Source: © 2017 Google LLC/AAIIC



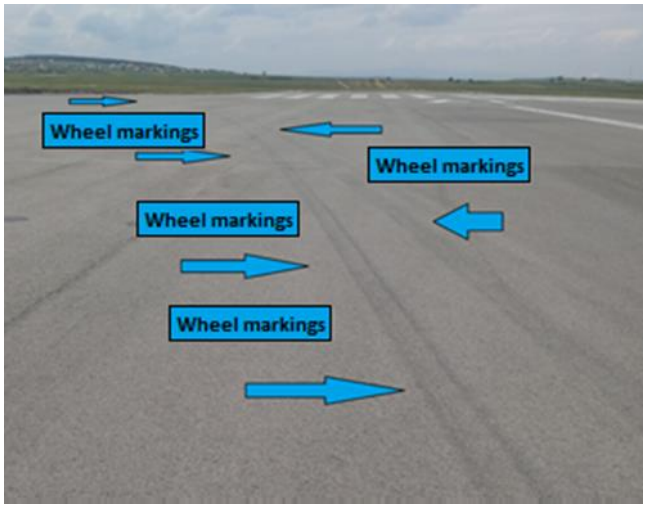


Image 9 & 10: Wheel markings on the runway Source: AAIIC

Image 11: Sketch of the final aircraft position Source: © 2017 Google LLC/AAIIC

Image 12: Damages on engine no.1 Source: AAIIC

1.12 Findings and Maintenance

The airplane's left engine was slightly damaged. Due to the runway excursion, the wheels sank into the mud and wet grass beside the taxiway. The left engine had ground contact and was damaged.

According to the information provided by the maintenance organisation of the operator there were several damages found:

Engine No.1: damages at the Nacelles

damages of the LH & RH Thrust Reverser

damages of the LH & RH Fan Cowl and the inlet cowling

damages of the Bleed Air Cooler

Because of the damage, the engine was replaced by the maintenance organization.

According to further more work orders provided by the maintenance organization other parts were also replaced:

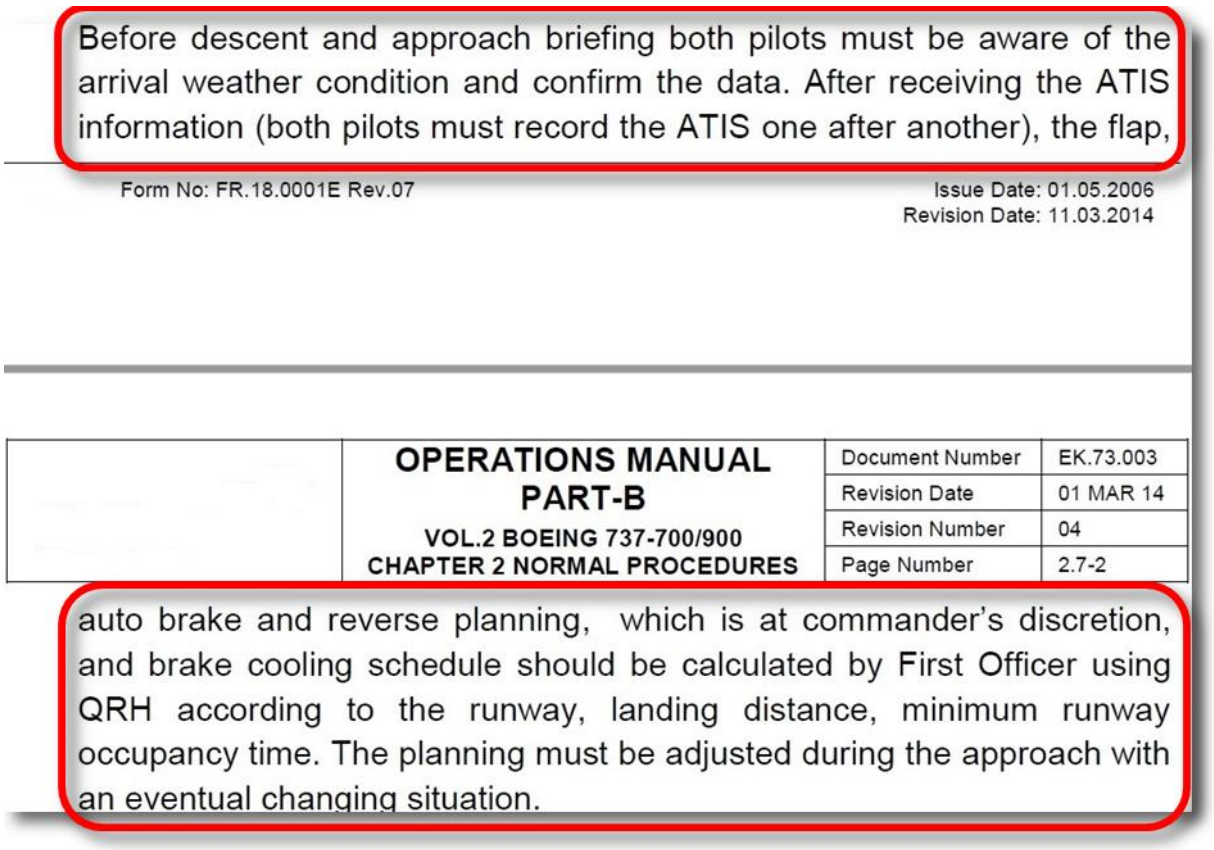
LH&RH Landing Gear Brake Units

Main Landing Gear Wheel Assemblies

After the maintenance work was completed, the operator's maintenance organisation performed a runway excursion Phase 1 & 2 inspection.

1.13 Organisational Information

The airline operator stipulated in the "Operation Manual Part-B, Vol.2", 1 March 2014, that pilots have to be respected the following before approach.



Before descent and approach briefing both pilots must be aware of the arrival weather condition and confirm the data. After receiving the ATIS information (both pilots must record the ATIS one after another), the flap,

Form No: FR.18.0001E Rev.07

Issue Date: 01.05.2006
Revision Date: 11.03.2014

	OPERATIONS MANUAL PART-B VOL.2 BOEING 737-700/900 CHAPTER 2 NORMAL PROCEDURES	Document Number	EK.73.003
		Revision Date	01 MAR 14
		Revision Number	04
		Page Number	2.7-2

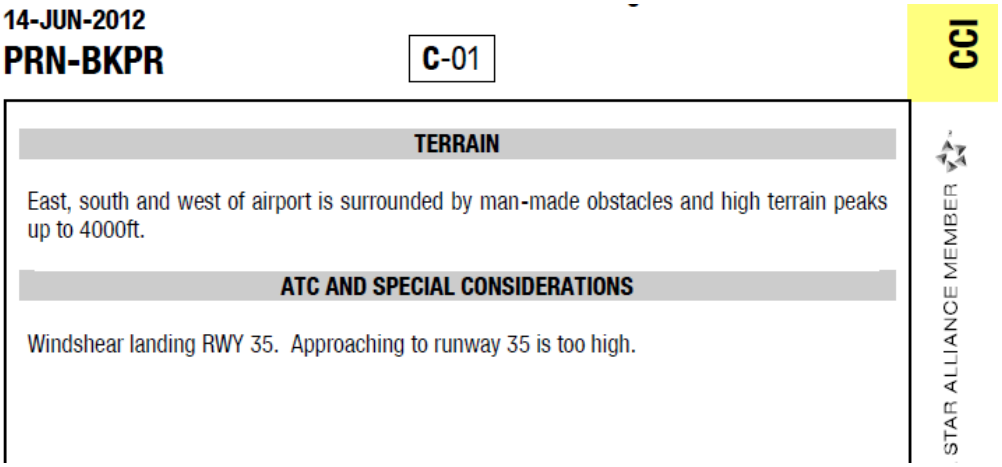
auto brake and reverse planning, which is at commander's discretion, and brake cooling schedule should be calculated by First Officer using QRH according to the runway, landing distance, minimum runway occupancy time. The planning must be adjusted during the approach with an eventual changing situation.

Image 13: OPS Manual Part-B, Vol. 2, 1. March 2014 Source: Airline Operator Manual

1.13.1 LIDO CCI-Chart

The operator has a special Lido “CCI-Chart” provided by Lufthansa Systems for Pristina International Airport “Adem Jashari”. The special note says:

Windshear landing runway 35 and approaching to runway 35 is too high.


14-JUN-2012

PRN-BKPR

C-01

CCI

TERRAIN

East, south and west of airport is surrounded by man-made obstacles and high terrain peaks up to 4000ft.

ATC AND SPECIAL CONSIDERATIONS

Windshear landing RWY 35. Approaching to runway 35 is too high.

STAR ALLIANCE MEMBER

Image 14: Lido CCI-Chart, valid from 14 June 2012 Source: Airline Operator/AAIIC

1.13.2 Approach Path

This graph shows the actual flight path flown in accordance to the assigned 3.47° flight path for the VOR / DME P runway 35 approach.

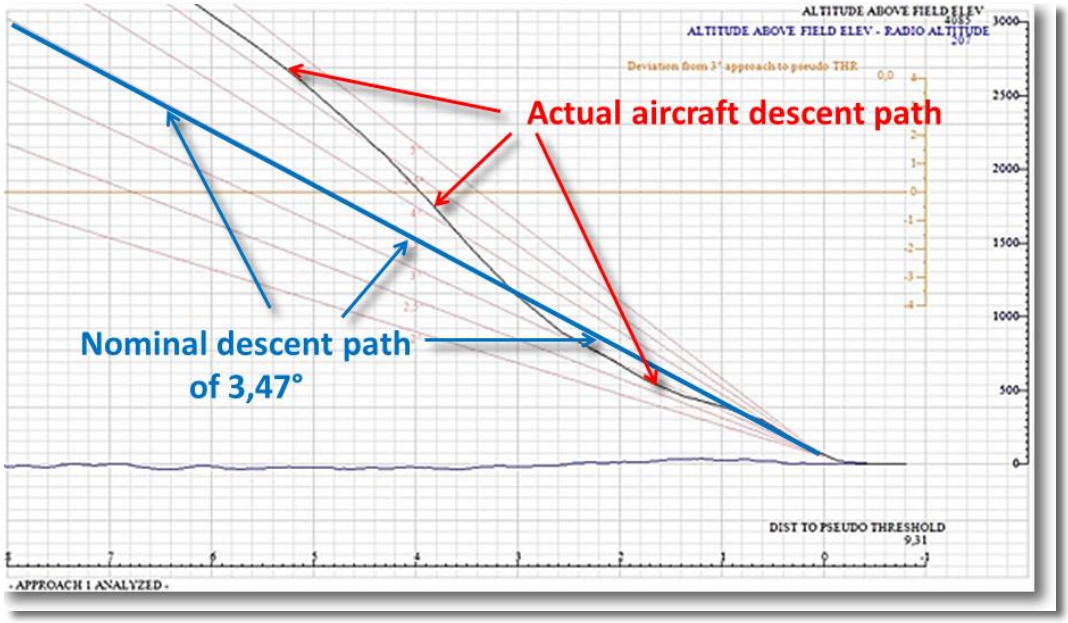


Image 15: Approach path runway 35 Source: Airline Operator/AAIIC

1.13.3 Wind Factor during the Approach

The airline operator provided a wind chart for the time of the approach. The starting point correlates with the time the Flaps were put in position 1 and ends at the time the aircraft touched down. The crew had planned a Flaps 40 landing. According to the chart a constant tailwind prevailed during the approach of the aircraft.

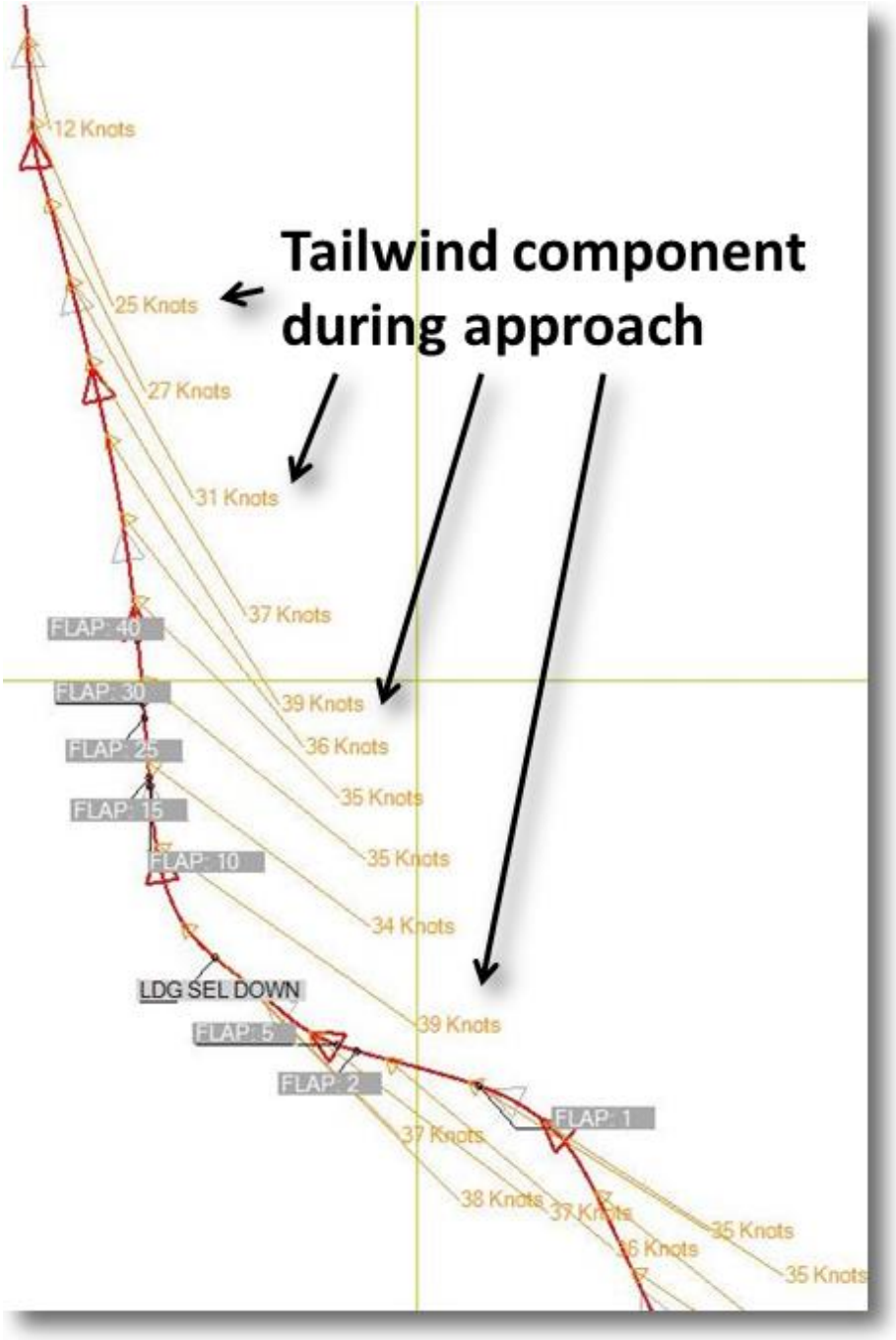


Image 16: Wind analysis during the approach Source: Airline Operator/AAIIC

1.14 Additional Information

1.14.1 General Information Regarding Aircraft on Wet Runway

The Boeing B737-800 is equipped with the following braking devices: ground spoilers, steel or carbon brake discs and thrust reversers. When the destination airport runway is considered to be wet, the crew should consider the following landing techniques according to “Flight Safety Foundation (FSF) ALAR Toolkit Briefing Note 8.4 Wet or Contaminated runways”:

- *Approach on glide path and at target speed.*
- *Aim for the touchdown zone*
- *Conduct a firm touchdown*
- *Use maximum reverse thrust*
- *Confirm extension of ground spoilers*
- *Do no delay lowering the nosewheel*

When stopping an aircraft, the pilot expects a deceleration that is proportional to the amount of wheel braking applied and to runway surface friction. Braking action is directly affected by friction between the tire and the runway surface. When the actual deceleration is less than expected, braking action is degraded. The degree to which deceleration by the wheel brakes is degraded is indicated by the use of the terms good (deceleration is normal and directional control is normal), medium (deceleration is noticeable reduced and directional control may be slightly reduced) and poor (deceleration is significantly reduced and directional control may be significantly reduced).

1.14.1.1 Autobrake System

A list of the Autobrake system setting of the Boeing B737-800 with the corresponding deceleration rates was extracted from the FCTM provided by the airline operator:

Autobrake Selector	Max Pressure at Brakes (PSI)	Deceleration Rate (ft/sec^2)
1	1250	4
2	1500	5
3	2000	7,2
Max	3000	12 (< 80 kt) /14 > 80 kt)

1.14.2 Procedures established by the Airline

1.14.2.1 The Boeing B737-800 Flight Crew Training Manual (FCTM) chapter 6.34 Slippery Runway Landing Performance

The Boeing B737-800 Flight Crew Training Manual (FCTM) chapter 6.34, June 30 2014, was provided by the airline operator. The manual provides the flight crew with slippery and contaminated runway advisory information. The information was provided by Boeing and is based on an assumption of uniform surface contamination condition over the entire runway. This means a uniform depth for slush or standing water for a contaminated runway or a fixed braking coefficient for a slippery runway. The data cannot cover all possible “slippery / contaminated runway” combinations and does not consider factors such as rubber deposits or heavily painted surfaces near the end of most runways. With these caveats in mind, it is up to the operator to determine operating policies based on the training and operating experience of their flight crews.

1.14.2.2 Landing Distance Tables

The following landing distance tables show the required runway length in meters for the corresponding landing weight of the aircraft with the configuration flaps 40. The information was found in the QRH, chapter performance inflight. The QRH of the Boeing B737-800 was provided by the airline operator.

According to the METAR the runway was wet. The Loadsheet indicated an estimated landing mas was 64 515 kg.

According to Pristina International Airport, breaking action measurement is not performed during the summer season and when it is raining. The breaking action is required only during the winter season and when there is a snowfall. Based on this data there were no braking action measurement performed before landing. After the runway excursion approx. 44 min, measurement of the breaking action was performed and breaking action was good.

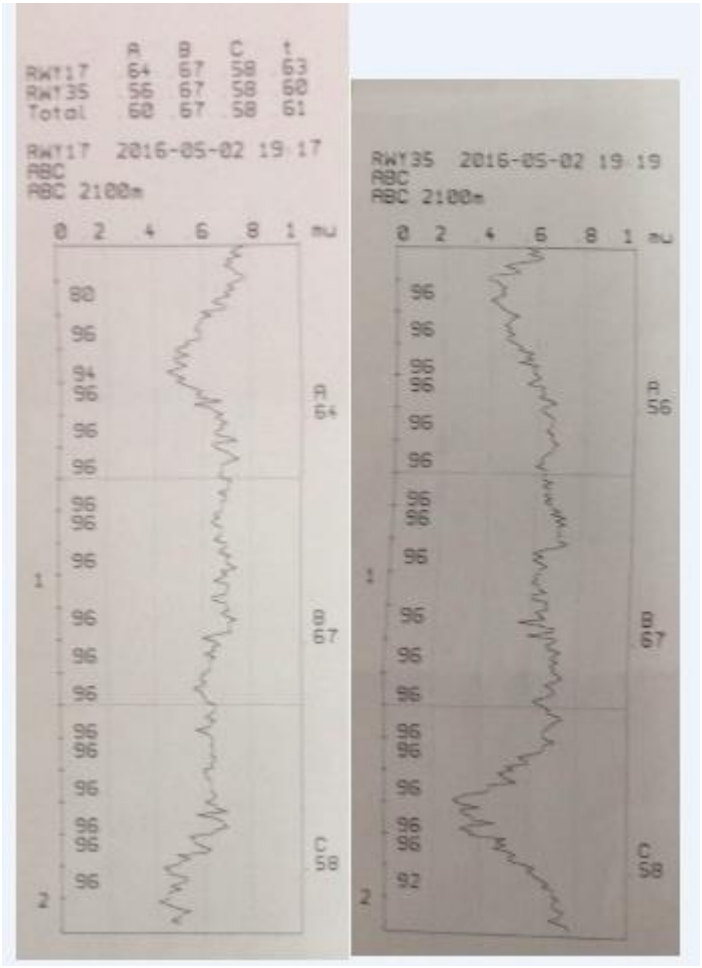


Image 17: Braking action measurement (20:17 hour should be because they did not correct time) Source: Airport

To measure the landing distance with the estimated landing mass of 64 515 kg two calculation with Flaps 40 were performed. The one calculation is with a dry runway and the other one assuming a wet runway with braking action good.

Dry runway calculation:

Autobrake 3: 1 590 m (REF DIST) + 85 m (WT ADJ) +85 m (ALT ADJ) + 305 m (WIND ADJ) = 2 065 m

Good Reported Braking Action:

Autobrake 3: 1 590 m (REF DIST) + 85 m (WT ADJ) +85 m (ALT ADJ) + 305 m (WIND ADJ) = 2 065 m

Performance Inflight - QRH
Advisory Information

BOEING

737 Flight Crew Operations Manual

737-800W/CFM56-7B26
JAA
Category C/N Brakes

ADVISORY INFORMATION

Normal Configuration Landing Distance

Flaps 40

	LANDING DISTANCE AND ADJUSTMENTS (M)								
	REF DIST	WT ADJ	ALT ADJ	WIND ADJ	SLOPE ADJ	TEMP ADJ	APP SPD ADJ	REVERSE THRUST ADJ	
BRAKING CONFIGURATION	65000 KG LANDING WEIGHT	PER 5000 KG ABV/BLW 65000 KG	PER 1000 FT STD/HIGH*	PER 10 KTS HEAD/ TAIL WIND	PER 1% DOWN/ UP HILL	PER 10°C ABV/ BLW ISA	PER 5 KTS ABOVE VREF40	ONE REV	NO REV
Dry Runway									
MAX MANUAL	915	55/-50	20/25	-35/115	10/-10	20/-20	35	15	35
AUTOBRAKE MAX	1135	55/-60	25/35	-40/140	0/0	25/-25	55	0	0
AUTOBRAKE 3	1590	85/-100	40/55	-70/235	0/0	45/-45	90	0	0
AUTOBRAKE 2	2030	125/-140	60/80	-95/330	20/-35	60/-60	95	35	35
AUTOBRAKE 1	2260	150/-165	75/95	-115/390	55/-65	65/-65	85	155	220
Good Reported Braking Action									
MAX MANUAL	1460	80/-85	40/50	-65/230	40/-35	35/-35	60	75	160
AUTOBRAKE MAX	1555	85/-90	40/50	-70/235	35/-30	40/-40	70	80	175
AUTOBRAKE 3	1840	100/-115	45/65	-80/275	10/-5	50/-50	110	5	15
AUTOBRAKE 2	2335	145/-160	70/90	-110/380	25/-40	70/-70	110	40	40
AUTOBRAKE 1	2600	175/-190	85/110	-130/450	65/-75	75/-75	100	180	255
Medium Reported Braking Action									
MAX MANUAL	1990	120/-130	60/80	-105/380	100/-75	50/-50	75	195	465
AUTOBRAKE MAX	2015	125/-140	65/80	-105/385	85/-70	50/-60	85	195	465
AUTOBRAKE 3	2070	125/-140	65/80	-110/390	80/-50	60/-60	105	175	450
AUTOBRAKE 2	2405	150/-165	70/100	-120/430	65/-65	70/-70	110	85	220
AUTOBRAKE 1	2615	175/-190	85/110	-130/465	90/-85	75/-75	100	195	315
Poor Reported Braking Action									
MAX MANUAL	2580	180/-185	85/115	-160/600	230/-150	70/-75	85	415	1070
AUTOBRAKE MAX	2590	180/-185	85/120	-160/600	230/-150	70/-75	85	415	1070
AUTOBRAKE 3	2600	180/-190	85/120	-160/605	225/-145	70/-75	100	415	1075
AUTOBRAKE 2	2725	185/-190	85/120	-160/615	215/-140	75/-80	105	335	955
AUTOBRAKE 1	2840	195/-205	90/125	-165/635	220/-150	80/-85	100	385	935

Reference distance is based on sea level, standard day, no wind or slope, VREF40 approach speed, two-engine detent No. 2 reverse thrust, and auto speedbrakes.
For max manual braking and manual speedbrakes, increase reference landing distance by 65 m.
For autobrake and manual speedbrakes, increase reference landing distance by 50 m.
Reference Distance includes an air distance allowance of 305 m from threshold to touchdown.
Reference distances and adjustments shown for GOOD, MEDIUM, and POOR have been increased by 15%.

***For landing distance at or below 8000 ft pressure altitude, apply the STD adjustment. For altitudes higher than 8000 ft, first apply the STD adjustment to derive a new reference landing distance for 8000 ft then apply the HIGH adjustment to this new reference distance.**

Image 18: Landing distance calculation based on the Boeing B737-800 QRH Source: Airline Operator QRH

1.14.3 Stabilized Approach Criteria

The Boeing B737-800 Flight Crew Operations Manual Vol.1, SP.16.14 stipulates the following regarding Approach and Landing:

> *"Establish a stabilized approach no lower than 1000 ft above the airport to improve windshear recognition capability."*

1.14.4 Airline Operator Procedures

In the Boeing B737-800 Operations Manual Part-B Vol.2 the airline operator stipulates the following about the landing flare:

"Long Flare must be avoided. This will increase the landing roll and stopping distance, and will increase the tail strike risk."

In the Boeing B737-800 Operations Manual Part-A, chapter 8.1.2.8 the airline operator stipulates the following:

"All landings shall be planned so as to attain a positive touchdown within the first 1000ft of the runway with selected landing flaps (as applicable) at the targeted approach speed."

1.14.5 Approach Speed

According to the FDR-Parameter the indicated speed at touchdown was approx. 5 kt above V_{REF} (Reference Airspeed).

1.14.6 Taxi Speed

The taxi speed was according to FDR data around 50 kt when the aircraft began deviating from centerline and departed to the left edge of the runway to the taxiway C. The airline operator defined in the Operational Manual OM-B Vol.2, chapter 2.14.1 stipulates the following:

"The maximum taxi speeds during long and straight routes is 30 knots and for turns and at the apron, 10 Knots. (In wet conditions, turns must be made with maximum 5 knots)."

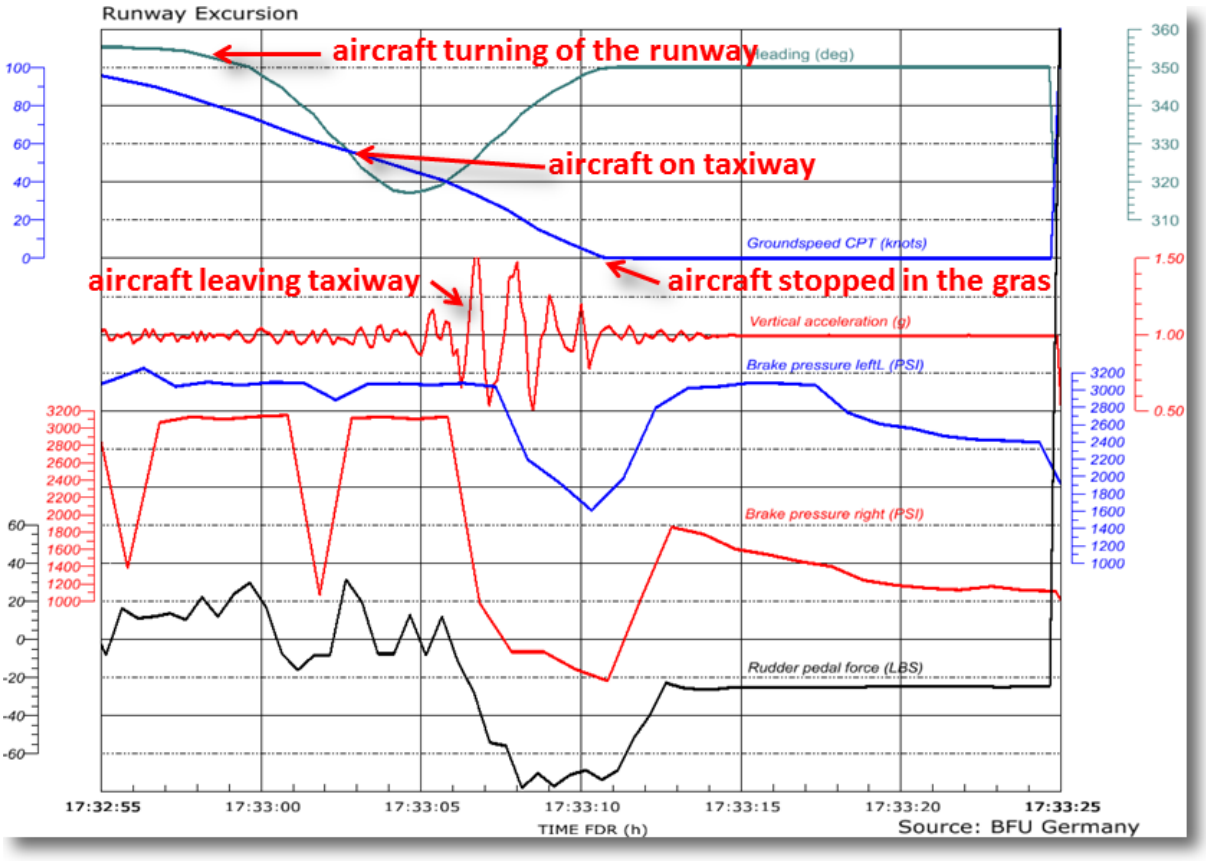


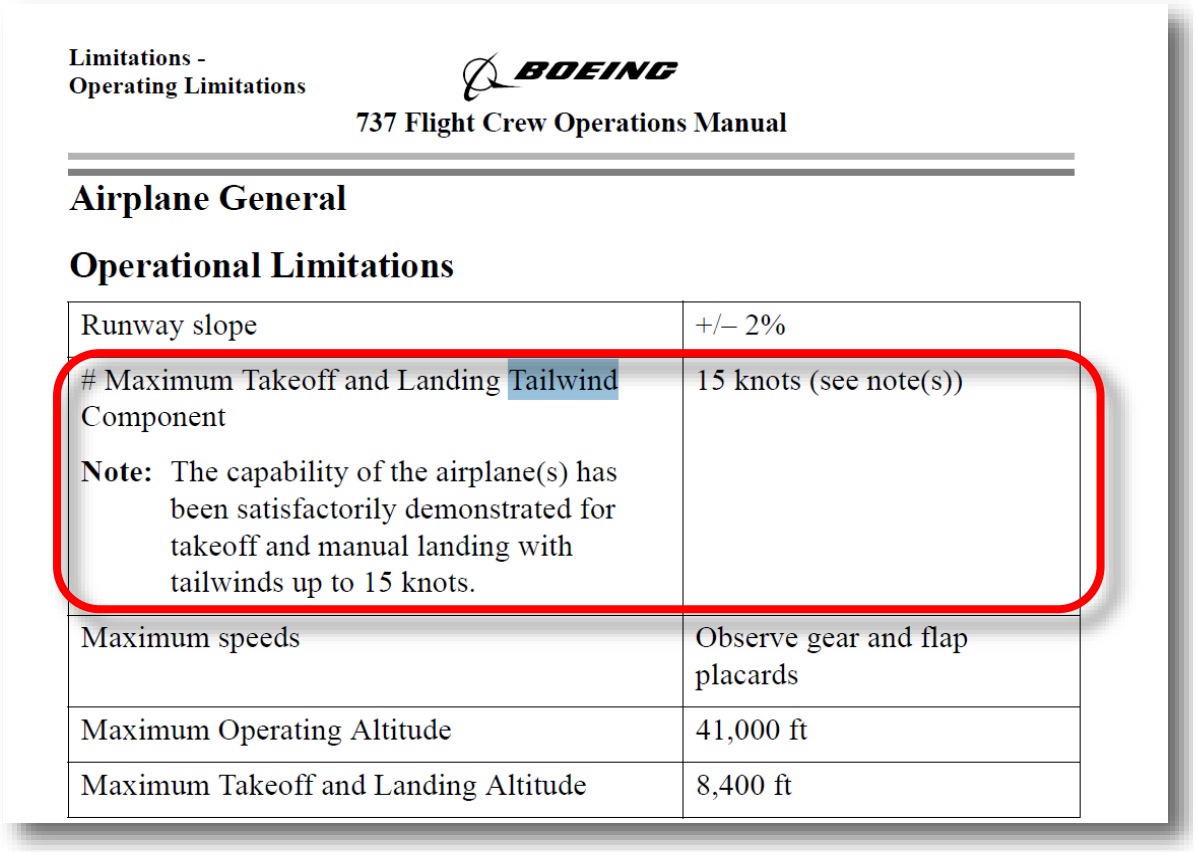
Image 19: Taxi speed during veering off runway Source: BFU/Germany

1.14.7 Tailwind Component

According to the Aircraft Flight Manual (AFM) and the Flight Crew Operating Manual (FCOM) maximum allowed tailwind component is 15 kt. The tailwind component the operator had calculated based on the wind conditions prevailing at the time of touchdown was approx. 13 kt.

The FCOM Chapter L "Operational Limitations" stipulates:

"The capability of the airplane(s) has been satisfactorily demonstrated for takeoff and manual landing with tailwinds up to 15 knots (see graph below for operational limitations)"



Limitations -
Operating Limitations

BOEING

737 Flight Crew Operations Manual

Airplane General

Operational Limitations

Runway slope	+/– 2%
# Maximum Takeoff and Landing Tailwind Component **Note:** The capability of the airplane(s) has been satisfactorily demonstrated for takeoff and manual landing with tailwinds up to 15 knots.	15 knots (see note(s))
Maximum speeds	Observe gear and flap placards
Maximum Operating Altitude	41,000 ft
Maximum Takeoff and Landing Altitude	8,400 ft

Image 20: Tailwind component, FCOM B737, Vol 1 L.10.2 Source: Operator/AAIIC

1.14.8 Operator landing procedure

There is no clear definition in the airline operation manual regarding the necessity of conducting a go-around in case of a landing not within the respective touchdown zone of the runway. According to the OM-Part A, chapter 8.1.2.8 the operator writes the following:

OM Part-A8.1.2.8 (E) suggests the following regarding touch down zone

"All landings shall be planned so as to attain a positive touchdown within the first 1 000 ft of the runway with selected landing flaps (as applicable) at the targeted approach speed."

1.14.9 Crew Resource Management

Crew resource management (CRM) is the use of all available resources to achieve a safe and efficient flight operation. The importance of proper CRM has been recognized by the industry over the years and training programs have been developed to teach crews how to improve decision making, communication, leadership, teamwork and management skills. These capabilities should effectively interact with standard operating procedures to get to a dominant effect on crew efficiency during routine and non-routine operation. Company culture and policies could affect CRM. References can be found in a various documents of "Flight Safety Foundation (FSF) ALAR Briefing Note 2.2 — Crew Resource Management".

In the Operating manual OM-A, Chapter 1.4 N the operator stipulates following regarding PIC:

(28) Shall conduct a pre-flight crew briefing (inclusive of the loadmaster, if applicable). Briefing shall be inclusive of the basis for an effective working relationship between the flight crew and other crew members with specific emphasis on Crew Resource Management (CRM). Items covered during this briefing shall be inclusive of the following minimum items:
(a) Establish effective communication between the flight crew and other crew members. Specific emphasis shall be made on the guidelines for the use of the Public Address (PA) and interphone systems.

The role of the first officer as pilot monitoring is to assist the pilot flying among other and by calling out the altitudes passing according the distances shown on the approach chart, however even calls were given by the co-pilot to stay on the runway. In the operating manual OM-A, Chapter 1.5.2 the operator stipulates following regarding the co-pilot assist:

"(8) To inform and assist the Commander, to ensure the safe and efficient conduct of the flight. Notwithstanding the overriding authority of the Commander, the Co-pilot shall not hesitate to suggest a better course of action if he is convinced that a decision of the Commander merits discussion. The Co-Pilot shall not hesitate to take control of the aircraft (if applicable, initiate a go-around, etc.) if he is convinced that the Commander's actions endanger flight safety or is convinced the Commander's status can be classified as incapacitated."

2. Analysis

2.1 Flight Crew Communication

On the CVR recording the impression was that the PIC showed a dominant behavior. The co-pilot addressed the PIC always with: “[…] captain”. That could be one indication of the authority structure between the co-pilot and the PIC.

Communication and crew resource management between the crew members during the flight was not in accordance with the Standard Operating Procedures (Operating manual OM-A, Chapter 1.4 (N) (28)) by the operator.

2.1.1 Handling during aircraft operation by the flight crew

During the flight according to the airline operator Standard Operating Procedures the pilot monitoring should assist the pilot flying with announcing within a non-precision approach the altitudes crossed in relation to the distances shown on the approach chart. The co-pilot in function as the pilot monitoring didn´t announce any of the altitudes. This would have prevented the high sink rates in the end phase of the approach and the EGPWS generated “Sink Rate” alert. Especially when according to the CVR recording both pilots noticed that they were getting too high on the approach path. The vertical sink rate was increased in order to capture the flight path again.

The flight crew didn´t perform a proper approach briefing including the tailwind component, go-around procedure and the runway surface contamination. Due to the long flare and the late touchdown, passing the touchdown markings, both must consider and initiate a go-around and consider conducting another approach.

Even the operator defined in the OM-A, chapter 8.1.2.8 that all landings shall be planned so as to attain a positive touchdown within the first 1 000 ft of the runway with selected landing flaps (as applicable) at the targeted approach speed.”

The runway threshold was passed at approx. 80 ft higher than normal threshold crossing height. This may have increased the landing distance by approx. 450 m. Due to the approx. 30 ft higher crossing of the threshold led finally to a long landing, approximately 100 m beyond the touchdown zone which equals approx. 1 030 m beyond the runway threshold.

As the PIC noticed that the runway length would not be sufficient to stop the aircraft on the runway, he tried to vacate to the left on the taxiway exceeding the maximum taxi speed stated in the Operational Manual OM-B Vol.2, chapter 2.14.1 by the operator.

2.2 Flight time regulation

According to the flight rooster of the cockpit crew there were no hints that the flight crew exceeded the crew flight time and rest time regulation.

3. Conclusions

According to the latest wind given by the tower controller and the actual METAR the flight crew were aware of the weather situation at the airport. With this information the PIC decided to continue the approach to runway 35 taking into account, the tailwind component and the longer landing distance due to the wet runway and reduced braking action were within the maximum allowed operating limits of the aircraft. A risk assessment before commencing the approach to runway 35 should have taken place. Therefor the decision to conduct an approach to runway 17 with headwind would have been the lower risk at that day. The decision to commence an approach with the higher risk or to change the approach with a lower risk relies on the decision of the PIC.
For this occurence flight the barrier to initiate a go-around manoeuvre timely didn´t take place.

3.1 Findings

- During the approach both cockpit crew members noticed that they were getting too high on the approach path.
- The aircraft passed the runway 35 threshold approx. 80 ft which equals about 30 ft higher than for the approach was defined. This led finally to a long landing, approximately 100 m beyond the touch down zone which equals approx. 1 030 m beyond the runway threshold.
- CRM during the flight was not according the Standard Operating Procedures by the operator
- Indicated airspeed at touchdown was approx. 5 kt above V_{REF} and a ground speed at the time was 162kts.
- Tailwind component from the wind analyses of airline operator at touched down was approx. 13 kt, but within the maximum allowed tailwind component.
- The flight crew attempted to taxi out of the runway on to a taxiway with a speed above normal taxi speed.

3.2 Causal Factors

The cause of this serious incident was the too high runway threshold crossing altitude combined with a long flare and late touchdown beyond the touchdown zone. The outcome was a touchdown approx. 1 030 m beyond the runway 35 threshold. Crew Resource Management was not performed according the SOP by the operator. The flight crew didn´t initiate a go-around procedure timely. This would have prevented the runway excursion.

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FDR and CVR:	Hans-Werner Hempelmann (BFU/Germany)