Verkehrssicherheitsarbeit für Österreich

FINAL REPORT

SERIOUS INCIDENT involving the aircraft type MD 88 on 31.07.2008 at approx. 17:34 UTC at Vienna Schwechat Airport (LOWW), Lower Austria

GZ. BMVIT-86.047/0001-IV/BAV/UUB/LF/2013

OVERVIEW

Austrian Civil Aviation Safety Investigation Authority

Translation of the original document in German. Only the German version of the text is binding.

The investigation was conducted as specified by Regulation (EU) No. 996/2010 and the Accident Investigation Act (UUG), BGBl. no. [federal gazette no.] 123/2005 in the current version. The exclusive purpose of the investigation is to determine the cause of the accident or serious incident to prevent future accidents or serious incidents. The investigation is not intended to determine guilt or liability. The investigation report restricts some content to preserve the anonymity of natural or legal persons involved in the accident or serious incident.

When referring to persons, the selected form will apply to both sexes.

This investigation report in accordance with Article 16 of Regulation (EU) No. 996/2010 was approved by the Head of the Austrian Civil Aviation Safety Investigation Authority (SUB/ZLF)on conclusion of the comment period as per Article 16 of Regulation (EU) 996/2010 in combination with Sec. 14 Par. 1 UUG 2005. Unless otherwise specified, safety recommendations are intended for the regulators that are responsible for the items addressed in the recommendation. The regulators are responsible for deciding specifically what action is to be taken.

All times in this report are in UTC (local time - 2 hours).

Federal Office for Transport
Austrian Civil Aviation Safety Investigation Authority
(SUB/ZLF)
Postal address: Postfach 207, 1000 Vienna
Office address: Trauzlgasse 1, A-1210 Vienna, Austria
T: +43(0)1 71162 DW 659230, F: +43(0)1 71162 DW 659299, E: fus@bmvit.gv.at

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Abbreviations

Abs	Paragraph
AFM	Airplane Flight Manual
AGL	Above Ground Level
AMM	Aircraft Maintenance Manual
APU	Auxiliary Power Unit
CM 1	Crew Member 1 (captain, in left-hand seat)
CM 2	Crew Member 2 (1st officer, in right-hand seat)
CS	Certification Specifications
CSN	Cycles since new
CSO	Cycles since overhaul
CVR	Cockpit Voice Recorder
EASA	European Aviation Safety Agency
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FBL	Airport Operations Manager
FCOM	Flight Crew Operating Manual
FDR	Flight Data Recorder
ft	foot
ILS	Instrument Landing System
LFZ	Airplane
LMT	Local Mean Time
LOWW	International code for Vienna Airport
LZIB	International code for Bratislava M.R. Stefanik airport
MD	McDonnell Douglas
METAR	inter alia METeorological Aerodrome Report
MTOM	Maximum Take Off Mass
NDT	Non destructive testing
NTSB	National Transportation Safety Board
P	Pressure
PIC	Pilot in Command
P/N	Part number
psi	pounds per square inch
QRH	Quick Reference Handbook
SIB	Safety Information Bulletin
S/N	Serial Number
SUB	Federal Safety Investigation Office
TSN	Time since new
TSO	Time since overhaul
TWR	Tower
UTC	Coordinated Universal Time
VIE	Flughafen Wien AG
WGS 84	World Geodetic System 1984
ZLF	Civil Aviation

Synopsis

• Aircraft manufacturer:	McDonnell Douglas, USA
• Type:	MD 88
• Nationality:	Spain
• Aircraft owner:	Air transport company
• Location of incident:	Vienna Schwechat Airport (LOWW)
• Coordinates (WGS 84):	N 48°06'39'' E 16°34'15''
• Altitude above MSL:	183 m
• Date and time:	31.7.2008, 17:34
• Light conditions:	daylight

- Brief resume:

The MD 88 aircraft took off from the Vienna Schwechat airport for Madrid on 31.07.2008 at 17:34 UTC. During the take-off run immediately before becoming airborne, the left engine experienced loss of power and vibration, as well as a smell of burning, upon which the pilots shut the engine off. The pilots returned to the airport and landed at 18:50. The aircraft was able to leave the runway under its own power.
The incident did not cause any personal injury, but the aircraft was seriously damaged.
The investigations by the Aviation Safety Investigation Authority showed that the unsecured valve stem on the rim of tyre 2 has worked loose and the O-ring underneath was torn apart, which had the effect of deflating the tyre. As a result, during the take-off run and past the point of decision, the tread of the tyre broke away, breaking off part of the water deflector attached to the left engine. The landing gear well was damaged, and then parts of the tread were thrown into the left engine, which caused loss of power and vibration, after which the engine was shut down.
A further consequence of the damage in the landing gear well was that no locking indication of the left-hand landing gear could be observed, and as a precaution the subsequent landing was performed in accordance with the "Landing with unsafe landing gear and possible evacuation of the aircraft" checklist.

The response team of the Austrian Civil Aviation Safety Investigation Authority was informed of the incident by the Search and Rescue Centre on 31.07.2008 at 18:00 UTC. In accordance with Sec. 8 Par. 1 of the Accident Investigation Act, the investigator in charge initiated an investigation of the serious incident and ordered the evidence to be secured.

In accordance with Annex 13 of the Convention on International Civil Aviation, the relevant countries were informed and invited to send observers. The following organisations assisted with the investigation:

Comisión de Investigación de Accidentes e Incidentes de Aviación Civil, Spain
Bridgestone, Belgium

1 Factual information

1.1 History of the flight

The history of the flight and the cause of the incident were reconstructed as follows based on radar data, statements by the pilots and air the traffic controller, the findings of the Vienna Schwechat airport operations director and investigators of the Austrian Civil Aviation Safety Investigation Authority:

The MD 88 aircraft took off from Vienna Schwechat airport for Madrid on runway 29 on 31.07.2008 at 17:34 UTC. As it took off, the left engine lost power and started to vibrate. The pilots retracted the landing gear, declared an emergency to air traffic control and started to turn downwind towards runway 29 with the intention of landing and climbed to 2000 ft MSL. A burning smell was detected in the cockpit but no smoke was seen and no fire alarm was triggered. The pilots wanted to perform a precautionary landing on runway 29 with a flight mass above the normal permitted value and on downwind they worked through the checklists for "Engine fire or severe damage or separation" and "Emergency return to the field", during which the left engine was shut down. They started the APU and switched on the connected power generator and hydraulic pump. The expected "landing gear extended and locked" indicator did not appear after extending the landing gear. The pilots then circled and worked through the "Abnormal gear indication with the handle down" checklist, including actuation of the emergency landing gear extension mechanism. However, the "Landing gear down and locked" indicatoion for the left main landing gear remained off. The pilots then decided not to land but about 8 minutes after take-off they conducted a low overflight over Vienna Schwechat airport at about 500 ft AGL to allow the air traffic controllers in the control tower to check the left landing gear. The pilots were informed that the left landing gear was extended. They then climbed to 5000 ft. In the meantime, the airport operations manager inspected runway 29 and found parts of a tyre and a part of a water deflector. Because of the missing locking indication, the pilots decided to inspect the locking mechanism of the main landing gears with a periscope in the passenger cabin of the aircraft. However, the CM 2, who conducted the inspection, could not obtain any information, because the field of vision was obscured by dirt.

Because the pilots wanted to have the information regarding the main landing gear verified again, 21 minutes after take-off they flew over the airport a second time at about 400 ft AGL, which gave them the same information as before. The pilots then climbed again south-east of the airport to about 5000 ft to burn more fuel and prepared for landing by working through the "Landing with unsafe landing gear and possible evacuation of the aircraft" checklist.

Once the flight mass had been reduced below the normal allowable landing mass, the pilots decided to land before dark, and decided to land on runway 34, because it is longer than runway 29 and has fewer obstacles on the left side. They were worried that the left landing gear could collapse and requested the presence of the airport fire brigade and a foam carpet, which however was not provided.

The Vienna Schwechat airport was placed in alarm priority 1 and subsequently alarm priority 2.

One hour and 16 minutes after take-off the aircraft landed smoothly on runway 34 at 18:50 UTC. During the landing, as a result of the actuation of the emergency extension mechanism, the inboard doors of the main landing gear scraped the surface of the runway

and caused a shower of sparks. The aircraft left the runway under its own power and stopped at exit 32, where the passengers could exit by stairs.
The pilots, crew and passengers were uninjured. The aircraft was seriously damaged.

1.2 Injuries to persons

Injuries	Crew	Passengers	Total on board	Other
Fatal	-	-	-	-
Serious	-	-	-	-
Minor	-	-	-	
None	6	116	122	
TOTAL	6	116	122	-

1.3 Damage to aircraft

Photo of the aircraft at the incident site on 1.8.2008 with tied up inboard landing gear doors
The left engine was seriously damaged. The left landing flap, the left main landing gear, the two inboard landing gear doors and the area of the left main landing gear well were also damaged.

1.4 Other damage

None.

1.5 Personnel information

CM 1

- Age / sex: 58, male
- Type of civil aviation licence: airline transport pilot licence
- Validity: valid on date of incident
- Qualifications: DC 9 Series
  Qualified instructor: yes
- Checks
  Medical check: 29.02.2008
  Proficiency check: 17.03.2008
- Flight experience (incl. incident flight)
  Total: 15.818 h
  in the last 90 days: 163 h
  in the last 30 days: 74 h
  in the last 24 hours: 1:16 h
  Flight service on date of incident:
  Flight time: 1:16 h

CM 2

- Age / sex: 38, male
- Type of civil aviation licence: airline transport pilot licence
- Validity: valid on date of incident
- Checks
  Medical check: 26.11.2007
  Proficiency check: 13.11.2007
- Qualifications: DC 9 Series
  Qualified instructor: yes
- Flight experience (incl. incident flight)
  Total: 5.246 h
  in the last 90 days: 131:30 h
  in the last 30 days: 67:52 h
  in the last 24 hours: 1:16 h

1.6 Aircraft information

- Manufacturer: McDonnell Douglas, USA
- Type: MD 88
- Serial number / year of manufacture: 53.309 / 1992
- Total operating hours TSN: 33.337 h
- TSO: 2.023 h
- Left engine: installed 20.6.2008
- Type: JT8D-217C
- Manufacturer: Pratt & Whitney
- Serial number / year of manufacture: 726.896 / 1992
- Total operating hours: TSN 27.822 h / TSO 9.150 h
- Operating cycles: CSN 23.488 / CSO 7.623

• Right engine:	installed 16.7.2008
• Type:	JT8D-217C
• Manufacturer:	Pratt & Whitney
• Serial number / year of manufacture:	725.901 / 1991
• Total operating hours:	TSN 33.076 h / TSO 13.545 h
• Operating cycles:	CSN 26.641 / CSO 11.677

Aircraft papers issued by:
Ministerio de Fomenta
Secretaria de Estado de Infraestructuras y Transportes
Direccion General de Aviacion Civil, Spain

- Registration certificate no. 3198, issued 3.4.2000.
- Airworthiness certificate issued 29.9.2005
- Certificate of use, issued 15.07.2008, for commercial transport, passenger transport, freight transport.
- Inspection certificate, issued 7.9.2007, time of next periodic inspection 7.9.2008.
- Noise level certificate no. 3504 issued 25.6.2008.
- Approval for an aircraft radio station, issued 7.9.2007.
- Confirmation of legally required insurance:
  Mapfre Empresas, policy no. 85/10.928 and 86/10.975, issued 26.11.2008, valid to 31.11.2009.

<u>General mass information:</u>

Maximum take-off mass:	66.678 kg
Maximum landing mass:	58.060 kg
Zero fuel mass:	50.000 kg

<u>Mass information for incident flight:</u>

Take-off mass:	approx. 61.300 kg
Fuel load:	approx. 11.600 kg
Landing mass:	approx. 55.000 kg

<u>Approval as per Minimum Equipment List (MEL):</u>
Deferred items: Right thrust reverser and auto brake

1.7 Meteorological information

1.7.1 Forecast

FXOS41 LOWW 311000
Flight weather outlook for Austria, valid for the Danube region and regions north of the Danube and Alp foothills and eastern border of the Alps for Thursday 31.7.2008 12:00 LMT
Weather conditions:
Austria continues to be in a stationary high influenced by unstable warm air. A cold front from the west is expected at Vorarlberg on Friday evening.

Weather prognosis:
Today Thursday increasing instability and development of first thunderstorms in the mountains, possible in the late afternoon also on the plains. Thunderstorms will dissipate in the first half of the night. Possible local hail.

1.7.2 Current weather conditions

Time of incident 17:34:

METAR LOWW – 31.7.2008:

SAOS31 LOWM 311720 RRA
METAR LOWW 311720Z VRB02KT 9999 FEW045 BKN160 25/20 Q1018 NOSIG=

SAOS31 LOWM 311750
METAR LOWW 311750Z 17006KT 9999 FEW045 BKN160 24/19 Q1018 NOSIG=

Landing: 18:50:

SAOS31 LOWM 311820
METAR LOWW 311820Z 16005KT 9999 FEW045 BKN160 24/20 Q1018 NOSIG=

SAOS31 LOWM 311850
METAR LOWW 311850Z VRB02KT 9999 FEW045 BKN160 23/21 Q1018 NOSIG=

The pilots were informed of a 4 knot tailwind while during the approach to land on runway 34.

1.7.3 Natural light conditions

Time of incident 17:34:
Daylight.
Sun position: Azimuth: 288°
Height: 8°

Landing 18:50:
Twilight.
Sun position: Azimuth: 302°
Height: -3°

Sunset on day of incident and site of incident:
19:09

1.8 Aids to navigation

Not applicable.

1.9 Communications

Not applicable.

1.10 Aerodrome information

Vienna Schwechat (LOWW) has two runways. Runway 11/29 is 3500 m long and 45 m wide, runway 16/34 3600 m long and also 45 m wide.
As a result of this serious incident, the Vienna Schwechat airport was closed to air traffic on the day of the incident from 18:56 to 19:00.

Bratislava airport (LZIB) has two runways. ILS runway 31 is 3190 m long and 45 m wide, ILS runway 04/22 is 2900 m long and 60 m wide.

1.11 Flight recorders

The aircraft was fitted with the specified flight data recorder (FDR) and a cockpit voice recorder (CVR).

1.12 Incident location and findings on the aircraft

1.12.1 Incident location, take-off runway 29:

After the aircraft had taken off on runway 29, parts of tyres and a part of a water deflector could be found in the area of the runway. No other parts could be found in a subsequent search on take-off runaway 29.

1.12.2 Landing runway 34:

After the aircraft landed on runway 34, the runway inspection found two approx. 20 cm parts of the skid of the left inboard door of the main landing gear.

Photo: Skid on the left inboard landing gear door

Photo: Skid on the left inboard landing gear door with broken off parts

1.12.3 Distribution and state of aircraft parts:

Part of the tread of a tyre was found in the area of the intake ring (FAN) of the left engine. All blades of the first compression stage were deformed or damaged, and the inner and outer intake ring was deformed in several places.

The bottom of the fairing of the left landing flap was penetrated in the area of tyre 2, where two pieces of tyre tread were found. The skids on the inner landing gear doors of the main landing gear were abraded. The skid on the inboard left landing gear door was broken with two approx. 20 cm long parts missing.

Bottom of punctured left landing flap with part of the tyre tread

Compressor inlet of left engine with part of the tyre tread, damage to the blades of the blower stage

Bottom of the inboard left main landing gear door

Left main landing gear with tied up, left inboard landing gear door

Tyre 2 was deflated with the tread detached. The water deflector was partly broken off. Tyre 1 had a pressure of 192 psi. The specified pressure is 200 psi. The lower tolerance limit is 190 psi.

1.12.3 Marks on the ground:

Take-off runway 29:

No marks were found on the surface of runway 29, which was used for take-off of the aircraft.

Landing runway 34:

Some traces of the contact of the inboard landing gear doors with the surface of the runway were found on runway 34 where the aircraft landed.

1.13 Medical and pathological information

There was no indication of impairment of the crew members.

1.14 Fire

Fire did not break out.

After the alarm was triggered, the airport fire brigade took up positions alongside runway 34 to provide fire cover for the aircraft as it landed.

A smell of burning was detected in the cockpit after the loss of power and vibration in the left engine.

1.15 Survival aspects

1.15.1 Emergency action:

When the pilots reported the failure of an engine after take-off at 17:34 UTC, a priority 1 alarm was triggered on runway 29, because at this stage a relanding on runway 29 was under consideration.

At 18:25 UTC the pilots decided to land on runway 34 and requested emergency personnel and a landing on a foam carpet, which resulted in a priority 2 alarm. The pilots were informed that a foam carpet was not available. The precautionary use of a foam carpet has not been part of emergency procedure for approx. 25 years, because it does not prevent fire nor does it have a cooling effect. It also reduces available extinguishing capacity. The new emergency strategy involves responding fire appliances as quickly and accurately as possible to the final location of an aircraft.

1.15.2 Evacuation:

The aircraft left runway 34 under its own power. Passengers were able to leave the aircraft by the steps, and the evacuation slides were not used. No persons were injured.

1.16 Tests and research

1. The inboard landing gear doors of the main landing gear:

Unlike the doors of the nose wheel and the outboard doors of the main landing gear, the two inboard doors of the main landing gear are hydraulically operated. When the landing gear is extended normally, these doors are opened and are then closed after the landing gear has been extended. If the emergency landing gear extension mechanism is operated, the door drives are depressurised and the landing gear and the doors drop down. In this case, the doors are disconnected from the hydraulic system and cannot be closed instantly, and they hang down in the air flow while the aircraft is flying. Skids of an aluminium-beryllium alloy are attached to the bottom edges of the doors to prevent damage during landing (and also during maintenance work).

During the landing, two pieces approx. 20 cm long broke off the skid on the inboard left landing gear door.

2. Damaged tyre 2 S/N: 507WC084:

The tyre, size 44.5 x 16.5-20, ply rating (number of carcasses) 28, was manufactured on 13 May 2007. It completed 225 take-offs (cycles) on another company aircraft of the same type. Because of a cut on the tread that exceeded the maximum allowable size, it was removed and returned to the tyre manufacturer for the first retread. As a result, the manufacturer issued a new EASA form 1 on 11. 3. 2008.

The company service department mounted the tyre on the rim in use in the incident on 11.7.2008. Among other tests, a 24-hour leak test at 200 psi was performed, during which the tyre was not moved or loaded. After that, the tyre was stored at a pressure of 40 psi, the storage pressure. A new EASA form 1 was issued to complete the service work and to be permitted to mount the tyre on an aircraft again.

The tyre-rim combination was mounted on the left main landing gear as tyre 2 (right-hand tyre of the left main landing gear) on 30.07.2008 and was recorded correctly in the aircraft logbook. The tyre-rim combination was mounted on the raised landing gear at the storage pressure of 40 psi as specified by the manufacturer's drawings, and then the pressure was increased to the operating level of 200 psi. Five flights were completed on 30.07.2008. On 31.07.2008, the date of the incident, the daily check was performed at 02:00 UTC and an actual pressure of 200 psi on the tyres of all four main landing gear wheels was confirmed with the signature of a qualified person.

Another five flights were completed on 31.7.2008 before the time of the incident. This shows that the total number of cycles of the right-hand tyre of the left main landing gear was 235 plus 10 since the tyre was placed back in service after the retread.

The tyre was completely deflated after the serious incident.

The inspection of the tyre showed that the vulcanised retread had become detached up to and over the shoulders of the tyre.

After the tread of the faulty tyre 2 had become detached, oval, almost concentric imprints were found at a position on both external layers.

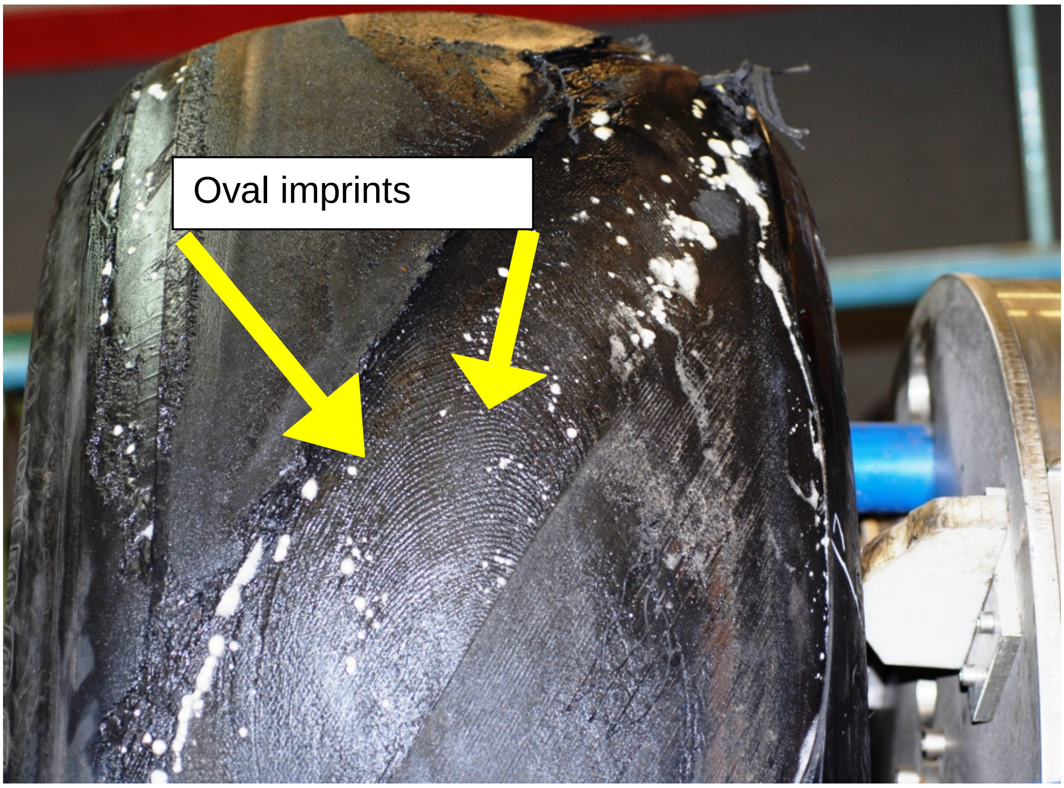
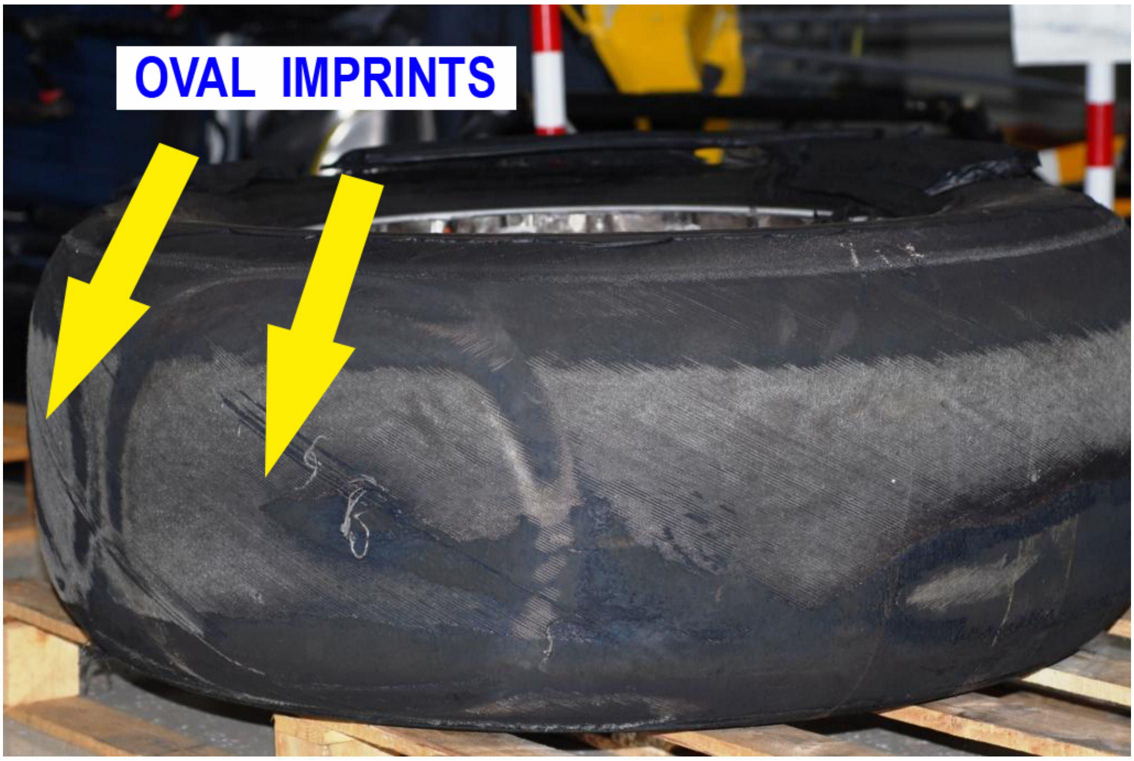


Photo: Damaged tyre 2 with typical traces upon detachment of the tread.

Additional oval imprints were found on this surface of the damaged tyre 2:



Damaged tyre 2 with typical traces of damage from touch down with a deflated tyre.

The surface of tyre 2 could not be fully reconstructed because it was not complete.

The tyres were taken to the tyre manufacturer and inspected in detail in the presence of employees of SUB/ZLF. Inspections in search of visible penetration of the outside and inside were unsuccessful. Tyre 2 was finally subjected to various pressure tests and found to have **no** leaks. When fitted with an intact sealing valve, the tyre was able to maintain the operating pressure.

The type of detachment of the tread, the oval imprints, the imprint pattern with the oval, almost concentric rings and the cracks in the inner lining on both shoulders of the tyre are typical signs occurring after a loss of pressure. The tyre manufacturer also noted that serious pressure loss in the tyre is sufficient to cause damage to the tyre such as that noted here after **one single take-off** of the aircraft.

3. The rim (P/N 5007897-2) of damaged tyre 2:

The rim, size H44.5x16.5-20, was manufactured in July 1989.

The rim parts were completely overhauled on 2.2.2008 (overhaul maintenance). This procedure requires removal and re-installation of the valve stem, including checking the tightening torque and replacement of the O-ring beneath the valve stem. The overhaul process was documented as specified.

When the tyre was mounted on the rim on 11.7.2008 and the rim-tyre combination was mounted on the aircraft 30.7.2008, removal and re-installation of the valve stem with a check of the tightening torque or replacement of the O-ring was not specified by the manufacturer. However, there are indications that the valve stem was removed. At the time of the incident the rim had completed 12,343 cycles, and 235 cycles since the overhaul maintenance.

Rim part of tyre 2 with valve stem screwed in

It was found that the thread of the valve stem with P/N TR761-3 was not locked to prevent unscrewing. Locking is not specified or planned.

After landing, the valve stem was found to be only hand-tight, and the O-ring beneath it was porous and broken.

Photo: Bottom of the valve stem of tyre 2 with porous, broken O-ring

The microscopic inspection of the O-ring showed that it was brittle and slightly greased on one side only. Impurities (probably brake dust) were found on the outer part.
The valve stem had no mechanical damage. The internal thread of the rim and the external thread of the valve stem were undamaged and the valve stem could be screwed in and out easily. The valve itself did not leak.

4. Overloaded tyre 1, S/N: 905WC232R4:

The tyre size was 44.5x16.5-20 and the ply rating 28. Visual inspection showed wear marks on the margins of the tread 34.5 cm apart. At the manufacturer comparative measurements of the distances between the wear marks on numerous tyres of the same size could be performed. The arithmetical average of the measurements was 31 cm. This means that the tyre was overloaded while rotating and therefore that the damaged tyre 2 was, at least almost, flat during operation.
The further inspection in search of visible penetration of the outside and inside was unsuccessful. The tyre was finally subjected to various pressure tests and found to have no leaks.
The visual inspection of the sidewalls of the tyre found cracks, also on the inside and outside shoulder of the inside liner. The visual findings were confirmed by shearography.
The cracks are typically found in tyres mounted in pairs if a single tyre is required to support the load of both tyres.

Detail view of inside layer of outer (left) shoulder

Detail view of inside layer of inner (right) shoulder

5. The rim of overloaded tyre 1:

The rim, size H44.5x16.5-20, was manufactured in July 1989. The valve stem of this rim was correctly screwed down. The valve stem had no mechanical damage. The internal thread in the rim and the external thread of the valve stem were undamaged and the valve stem could be screwed in and out easily. The O-ring under the valve stem was undamaged, correctly greased and had no signs of brittleness.

6. The indicator system showing the position of the locking mechanism of the main landing gear:

The main landing gear is locked in extended position by a spring-assisted over-centring mechanism. The indicator system uses a single proximity switch on both sides of the main landing gear. The electrical connection to the proximity switch in the left main landing gear well was broken by impact from flying tyre parts. This meant that during take-off and before retracting the extended left landing gear it was not possible to show a positive locking indication in the cockpit. The pilots did not notice this at the time.

7. Visual inspection of the main landing gear lock:

In this model of aircraft the pilots can from the passenger cabin check in flight that both landing gears are locked when extended using a periscope and visual marks. The complete landing gear cannot be viewed by this method. The pre-flight check specified by the aircraft manufacturer and also the airline company requires maintenance of the visual marks.

7a. Company checklist:

The company checklist for the emergency procedure "Abnormal Gear indication with the Handle Down" lists this option for observation of the landing gear and it was also used by the CM 2 during the incident flight. However, dirt made it impossible to confirm that the landing gear was locked.

It is known that the visual marks in the landing gear well are easily covered with dirt, thereby making visual inspection impossible.

7b. Aircraft manufacturer's checklist:
The aircraft manufacturer's checklist for the locked landing gear does not list this substitute method of visually checking the "gear down and locked" position of the landing gear with the periscope. The manufacturer gave the following reasons:

(a) The periscope is a secondary means to the existing AFM/FCOM procedure to verify that the gear is down and locked.
(b) The periscope is not a FAR Part 25 requirement .
(c) Information obtained on gear position from the periscope may be inconclusive.
(e) In today's congested terminal environment, it is not the best solution to have one crewmember of a two crew airplane, out of the cockpit while flying in an abnormal configuration.
(f) The design and operation of the cockpit security safety systems for cockpit doors system makes visual gear down lock via the periscope a less desirable option.

1.17 Organisational and management information

1.17.1 Maintenance operation of the company:
The approved maintenance operation had prepared a maintenance schedule for all work on tyres and rim components.

Information in the Aircraft Maintenance Manual (AMM):

<u>1. Tyre replacement as per AMM 32-40-01:</u>

B. Install Wheel and Tire:

…….

(5) Check fusible plugs, pressure release plug, and air inflation valve, installed in inner wheel half, for proper installation and condition.

<u>2. Daily Check, page 4/5, specifications for tyre pressures:</u>

….

MD 88, Main Landing Gear: Normal (psi) inflated press: 200

Notes:

1. *If P read < P norm less than 10 psi, inflate till P norm*
2. *If P read is between 10 and 20 psi less than P norm inflate till P norm and note in on the Flight Report book. If this happens twice, replace the wheel.*
3. *If P read is between 20 and 30 psi less than P norm replace the wheel.*
4. *If P read is 30 psi (or more) less than P norm replace the two wheels of the same axle.*
5. *….*

<u>3. Tyre pressure check:</u>

The tyre pressures must be checked once a day regardless of the number of landings in accordance with the applicable AMM of the aircraft manufacturer and the procedure is described in detail there.

4. Valve stem and O-ring:

The rim manufacturer specifies removal and inspection of the valve and replacement of the O-ring only during overhaul of the rim.

In contrast, the company stated that the O-ring is always replaced whenever the tyre is changed and the valve is removed. The reason given is to prevent damage to the valve stem.

However, a work card and quality assurance of the conclusion of the completed work are not specified for this work, particularly not for the correct return of the wheel to service. Confirmations of these alleged tasks, particularly for correct re-installation of the valve, are therefore not available and could not be produced.

5. Securing the valve stem:

According to the operator of the aircraft, this wheel was the last in the entire fleet in which the valve stem was not secured. The company also noted that some loose valves had previously been found to have been in service in the maintenance department.

1.17.2 Low overflight:

The decision by the pilots to delay the landing and to make a low overflight over Vienna Schwechat airport to allow the air traffic controllers in the control tower to get information on the status of the left-hand landing gear was made shortly before the overflight. The overflight was approved by the air traffic controller. According to his statement the pilots were given on the first as well as on the second overflight no directions regarding the route to follow. To the question of why the second overflight was not made along a runway and the observations were not conducted by a person on the runway, the answer was that a flight technician for the MD88 was not available at Schwechat airport.

According to the ACG, the air traffic controllers at Schwechat airport do not give pilots route or height directions during overflights for visual inspection of landing gears. The pilots arrange a corresponding overflight procedure with, for example, their technicians.

Austro Control GmbH. provided the following comment during consultation:

"According to the statement of the air traffic controller, the overflight along the runway was in this case not an option for a number of reasons:

The pilot requested this and the air traffic controller would always try to follow the pilot's requests in an emergency situation such as this, because he is responsible for the aircraft and is the only person who is familiar with the condition of the aircraft."

Flughafen Wien AG stated the following during consultation:

"In normal cases aircraft that want a check of the landing gear from the ground always want the published approach procedure and ground crew (depending on availability) organised by the airport operations director observe the overflight near the runway to provide information to the PIC via TWR."

1.17.3 Obstacles in the area of Schwechat airport:

The most and highest obstacles in the area of Schwechat airport are north of runway 11/29 and west of runway 12/34. Both overflights were in this area. The investigations showed that the heights of the obstacles in the area of the airport and also in the immediate region of Vienna Schwechat airport are in some cases unknown.

During one overflight one of the obstacles flown directly over was a lattice mobile phone tower at a height of 735 ft MSL, which was difficult to see.

1.18 Additional information

1. Company:
   As of 01.08.2008 the company stopped using the entire MD 88 fleet for commercial passenger transport and subsequently phased out the aircraft.

2. Tyre parts in engines of aircraft of the same type:
   Numerous cases in which parts of tyres have damaged the structure and engines after tyre damage are known for aircraft of this type.

3. See http://www.ntsb.gov/doclib/reports/2010/AAR1002.pdf for an accident report prepared by the National Transportation Safety Board (NTSB) for a Bombardier Learjet 60 in Columbia, South Carolina, on 19 October 2008. The report includes a discussion of causes and effects of aircraft tyres that were not correctly inflated. Detached tyre parts subsequently damaged electrical equipment in the wheel well, which had serious and wide-ranging consequences.

4. One example of a serious incident which required an overflight, because the pilots had no way of making their own inspection:
   An Airbus A320-232 took off from Burbank airport (KBUR) on a flight to New York (KJFK) on 21 September 2005. There were 140 passengers and six crew members on board. After take-off the landing gear could not be retracted. Because the pilots had no way of checking the status of the landing gear, they made an overflight over Long Beach Municipal Airport (KLGB) to allow persons in the control tower to inspect the landing gear. Both engines were operational during the overflight.

5. Extract from the MD-88 Operations Manual, instrument approach with one engine not operational:

   "Note: Aircraft may not maintain level flight with one engine inoperative at Flaps 28"

6. EASA Safety Information Bulletin No. 2013-10:
   Based on Safety Alert for Operators (SAFO) No. 11001 issued by the Federal Aviation Administration (FAA) issued on 6 January 2001, referring to correctly inflated aircraft tyres, EASA issued EASA Safety Information Bulletin No.: 2013-10 (see attachment at the end of this report).

1.19 Useful or effective investigation techniques

Not applicable

2 Analysis

2.1. Flight operations aspects:

When analysing this incident, note that the pilots had virtually no information about the cause of the incident and only restricted information about the status of the left engine and the left main landing gear.

The first indication of an incident in the cockpit during take-off run was that the left green locking indicator light of the left main landing gear went out, which was caused by interruption of the electrical connection to the proximity switch. The pilots did not notice this at the time. Immediately after the indicator light went out, the pilots' attention was drawn to the occurring engine problem. They then retracted the landing gear according to the checklist, although based on the arisen damages there were three reasons it would have been better to have left the landing gear extended:

First, an extended landing gear would have been required for the short term relanding because of the engine problems, secondly, it was proven that the extended landing gear was locked in spite of the now missing locking indication, and thirdly, parts of the detached tyre tread could have become jammed during retraction of the landing gear and still block the lowering mechanism that was, as in this case basically still functional.

The first problem noted by the pilots during take-off was the loss of power and the vibration of the left engine and the detection of a burning smell.

The following emergency procedures in case of power loss were at choice:

1. "Engine fire or severe damage or separation"

   Following this checklist the engine will be shut down.

   In this incident, the crew decided to proceed as specified by this checklist.

2. "Engine Compressor Stall"

   Following this checklist the power of the engine will be reduced or, if not avoidable, will also be shut down. Partial thrust could still be available.

   Because the company specifically requires the "Engine fire or severe damage or separation" checklist to be followed in the event of any power loss during take-off, the pilots did not consider using the "Engine Compressor Stall" checklist.

3. "Air Condition Smoke/Fumes"

   Following this checklist will, among other items shut down the cabin air supply.

   The pilots did not use this checklist, because although they did detect a strong burning smell they could not detect any smoke, which is a requirement for proceeding in accordance with this checklist. The pilots also stated that the burning smell disappeared after a few minutes after working through checklist 1.

   If foreign bodies penetrate the engine and burn, the bleed air can bring a burning smell into the air supply system and as a result a burning smell gets into the passenger cabin and cockpit.

   Because the left engine was continuing to vibrate after reducing the power, the pilots decided to proceed with checklist 1 "Engine fire or severe damage or separation", and thus to shut down the engine, actuate the extinguisher system and to shut off the bleed air supply. The company operational regulations specify proceeding with the "Engine failure during take-off" procedure for the subsequent departure, which among other items sets the climbing pattern and the flight path.

   The decision by the crew to proceed with this checklist is understandable because of the information available to them at this stage, but it was not the most useful decision.

The best decision would have been to set the engine to idle, shut off the left air-conditioning system and to climb to a higher altitude. Based on the damage that had occurred, the values displayed if this procedure had been followed would most probably have remained constant and the damaged engine could have continued to idle until the final landing. This means that the pneumatic, hydraulic and electrical systems, low power reserves and also the left thrust reverser would have remained available.

However, at this point the pilots were only aware of an engine problem of unknown origin and after shutting down the engine decided to proceed with the applicable emergency procedure, which specifies an immediate landing.

They declared an emergency.

The pilots were then confronted with another problem that had been unknown to them up to this point, when the green locking indicator light for the left main landing gear remained off after extending the landing for the planned landing. However, the locking indicator light was only off because the electrical components of the proximity switch had been disconnected by the detached tyre tread. After actuation of the extension mechanism, the cockpit crew could not tell whether the gear was locked. However, the landing gear was actually extended and locked.

The reason for the failure of the left green locking indicator light could have been as trivial as the failure of the globe.

In this aircraft type the pilots also have the option of inspecting the locking mechanism of both sets of main landing gear with a periscope in the passenger cabin. However, this option was only included in the company checklist, not the manufacturer's checklist. The complete landing gear cannot be viewed by this method.

Because of the lack of a locking indication in the cockpit in this incident, the pilots decided not to land immediately but to have the CM 2 use the additional option of inspection by periscope. However, this was not possible because the field of vision was obscured by dirt.

It is known that visual marks in the area of the landing gear well become obscured by dirt during operation.

The aircraft manufacturer's preflight checklist specifies a partial check of this option of inspection by the periscope in the area of the landing gear.

However, the aircraft manufacturer's checklist for this emergency procedure notes that the periscope and the view through it are not significant compared to the displays in the cockpit. The manufacturer's comment to the draft of this incident report gives the following reasons for removing the observation with the periscope procedure from the checklist:

(d) The periscope is a secondary means to the existing AFM/FCOM procedure to verify that the gear is down and locked.
(e) The periscope is not a FAR Part 25 requirement.
(f) Information obtained on gear position from the periscope may be inconclusive.
(g) In today's congested terminal environment, it is not the best solution to have one crewmember of a two crew airplane, out of the cockpit while flying in an abnormal configuration.
(h) The design and operation of the cockpit security safety systems for cockpit doors system makes visual gear down lock via the periscope a less desirable option.

The comment for (a) shows that the manufacturer does not wish to give priority to observation with the periscope.
The comment for (b) is correct, but it is not an argument for not using an available means of observation.
The comment for (c) appears to be the most significant. However, it is not clear exactly what this comment actually means. If it is actually not clear that an observation using the periscope is not reliable for any specific reason, this observation system should have been specifically deactivated and also the question arises why the company should have referred to this observation option in the checklist at all.
The comment for (d) refers to a consideration that is important, but it is not necessarily an argument why an available option for observation should not be used by the crew after they have assessed the overall situation.
The comment for (e) is not clear. The pilots often leave the cockpit during flight. However, the cockpit door security system remains available.
Although the option for observation of the landing gear with the periscope is not listed in the manufacturer's checklist, this equipment should still be included in the preflight check. But it makes no sense to maintain equipment that is not used in the corresponding procedures or in the manufacturer's opinion should not even be used.
However, it is possible that the integration of this aircraft model in the product line of this aircraft manufacturer had resulted in unification of the operational procedures for reasons of common processes. It is also possible that the continuing partial maintenance of the periscope has simply been overlooked.

If we assume that the CM 2 had been able to see the marks of the landing gear locking mechanism through the periscope during flight and had therefore been able to conclude that the main landing gear was locked in an extended position:
The contradiction in the checklists would have had significantly different effects on the further course of the flight depending on whether the pilots had followed the company or the manufacturer's checklist.
If they had followed the company checklist, the incident would have been limited to a return landing with a failed engine, in this case a short flight with only one engine in operation. A landing of this type is the subject of regular routine training.
If the manufacturer's checklist had been followed, because any mark for the landing gear locking mechanism have no allowed influence on the indicators in the cockpit, the pilots would also have had to land with a failed or shutdown engine and they would also have had to use the "Gear unsafe" checklist. In this case, they would be required to work through a complex, detailed procedure that required an emergency landing with specific behaviour by passengers and crew. The landing would also be conducted without spoilers and with a different landing technique. This procedure extends the flight time, which would also increase the possibility that the remaining engine could also fail.

The occurrence of different incidents requires decisions on how the emergency procedure is to be applied for the individual incidents. The sheer number of combinations of possible incidents means that no where near all of them can be included in checklists. The sequence in which the emergency procedure is processed is also important. The decisions require a correct assessment of the overall situation, which assumes accurate recording of the current status. The occurrence of two

incidents, each of which could be systematically managed separately without difficulty, can in combination lead to completely different risks and required actions. Therefore, the procedures required by different emergency procedures may be contradictory. The best possible solution for a multiple incident scenario cannot simply be to apply procedure for the first incident applied to the second incident, but would be a different view that recognises the overall problem and takes all aspects into account. Multiple incidents cannot be managed simply by working through the checklists for individual incidents in sequence. This means that persons dealing with the incident must be open to changes in plans.
If the only problem had been a failed landing gear indicator, a low overflight with two operating engines would have involved a lesser risk. However, in this case the low overflights with only one operating engine and a high flight mass increased the risk. The consideration that another fault in the remaining engine that was being operated at maximum continuous power would not guarantee a safe flight was also mentioned by the pilot in command in another context in his comment.

After the locking indicator for the left main landing gear did not light, the pilots decided to discard the original plan for an immediate landing specified by the "Severe engine damage or separation" emergency procedure, and made two low overflights, approved by the air traffic control manager, to allow the air traffic controllers in the control tower to assess the status of the left main landing gear. They flew past approx. 280 m from the tower and at about 500 ft and 400 ft AGL they were approx. 200 ft and 100 ft higher than the tower and were therefore outside the applicable procedures and below the circling minimum descent altitudes and also below minimum radar altitudes. They flew over numerous buildings, a tank farm and a poorly -visible mobile phone lattice tower 735 ft above MSL. The climb gradient after the overflights with only one operating engine and the landing gear extended was greatly restricted at about 1.2% and required visual avoidance of obstacles; however the flight visibility was adequate. If the remaining engine had failed during the low overflights, the consequences could have been especially serious with the built-up areas below and the chemical plants adjoining north-west of the airport (including an oil refinery).
The statement of the air traffic controller that pilots presently are not directed to follow a specific route or altitude during low overflights was confirmed by the ACG during consultation.

During consultation, the air traffic controller stated that the overflight along a runway was not an option in this case for several reasons.

Even though it is desirable to follow the wishes of pilots in emergency situations, an air traffic controller should also attempt to reduce the risk as much as possible, e.g. with reference to local conditions. If a low overflight is permitted over areas with numerous obstacles where the pilots do not know the exact locations and heights and are flying a defective aircraft, this leaves the safety of the low overflight partly due to chance.
In contrast to the statement by the air traffic controller, the pilots did not have accurate information about the status of their aircraft.
Flughafen Wien AG has noted that in a normal case of a landing gear check in flight the published approach procedures are followed.

The inspection of the landing gear during flight by persons on the ground is inherently effective only to a very limited extent, because they can only assess the general position and completeness of the landing gear but not whether it is locked. A missing locking indication in the cockpit means that in this case the only singly designed sensor system of the left main landing gear cannot detect the locking of the landing gear when extended. If the landing gear is not actually locked in extended position, the actual position of the landing gear is not significant.

Low overflights along the runways and the adjoining approach and departure routes could have reduced the risk because of the largely lack of obstacles. Even if the pilots had to make a very quick decision for the low overflight, it should have been performed at as low a risk as possible, particularly when considering the status of the aircraft.

A technician on a runway under the flight route would have had the best view of the situation before the second overflight.

A technician qualified for that specific aircraft type is not absolutely essential for assessment of the general status of landing gear and/or to observe whether the landing gear is extended or not.

After the two overflights, the pilots retracted and extended the landing gear several times in the hope that the locking mechanism could be restored to operation. However, the repeated extension and retraction of the landing gear with unknown extent of damage could also have left it jammed in the landing gear well. The repeated extension and retraction could also have left the landing gear in a different status or in a different position from that observed by personnel on the ground during the two overflights, making the result of the observations obsolete.

After the second overflight at approx. 400 ft AGL, the pilots climbed to 5000 ft to burn more fuel to reduce, in accordance with the emergency procedure the landing weight of the aircraft for landing with the left landing gear in an unsafe status. The resulting reduction in the weight of the fuel was sufficient. The indications did not change while the landing gear was extended and retracted several times. The locking indication of the left landing gear remained off. The pilots then decided to actuate the emergency extension mechanism for the landing gear, after which it could only have been retracted with the supplementary step "Stowage of the emergency extension lever". An extended landing gear generates more drag (and requires more engine thrust), which is also increased by actuation of the emergency extension mechanism, because the large inboard doors of both main landing gear wells are not closed, in contrast to the standard extension procedure, but remain hanging in the airstream. The pilots wanted to land before the end of evening civil twilight.

The pilots requested a foam carpet for the landing. The precautionary use of a foam carpet for an emergency landing has not been state of the art any more of emergency action for about 25 years. This also raises questions about the training and continuing education of the pilots.

The pilots decided to land on runway 34, because it is longer and has fewer obstacles to the sides. This was the correct decision for Schwechat airport. However, a problem with the landing gear on one side particularly involves the possibility of the aircraft slewing to one side during landing. In such an incident a wider landing runway with ILS could have been preferable to a longer runway. The two runways at Vienna airport are 45 m wide, while the M. R. Stefanik airport in Bratislava (LZIB), only about 30 NM away, has ILS runway 22, which is 2900 m long and 60 m wide. It is not known whether approach charts for the airport in Bratislava were available on the aircraft. The pilots should have landed at the "nearest and most convenient airport", as specified by the checklist that they used. Because the pilots took off from Vienna Schwechat airport and were exclusively in radio contact with this airport, Schwechat seemed to be the obvious destination for the planned emergency landing. According to the comments by the crew, Bratislava airport was not considered for a landing for two reasons: First, because in the opinion of the crew it was too far from Schwechat airport, and second, if the remaining engine had failed, Bratislava airport was beyond the gliding distance of the aircraft.

Because Bratislava airport is approximately east of Vienna airport and the flight path of the incident flight was primarily south-east of Vienna, the aircraft was still closer to Bratislava airport on some parts of the incident flight. Therefore a landing in Bratislava could have been a consideration because of the wider runway 22.

Approximately one quarter of the incident flight was outside the aircraft's gliding distance from Schwechat airport.

2.2 Results of the investigation:

2.2.1 Damaged tyre 2:

Because no items other than parts of the tyre tread and a part of a water deflector could be found during the search of runway 29, and inspection of the parts of the tread gave no indication of impact by foreign parts, it can be concluded that the tyre was not damaged by the effect of foreign parts.

The tread of the tyre had become detached; the tyre was deflated. However, several subsequent tests by the tyre manufacturer found that the tyre did not leak.

This means that a deflated tyre as a result of a leak can be excluded.

Oval imprints, which were only formed during final landing, were found on the remaining surface. An oval-shape fracture pattern could also be found, from the centre of which the tread detachment started.

The type of detachment, the oval imprints, and the fracture pattern with the oval, almost concentric rings are typical signs of the consequences of loading of a tyre after a loss of pressure. The indications of overload on tyre 1 of the left main landing gear confirm these findings.

The fact that not all parts of the tread could be found can be explained because an unknown number of pieces were burnt in the engine.

It is very probable that the tyre had started losing its integrity during the flights preceding the incident. It can therefore be assumed that the tyre was not fully intact after landing in Vienna. An incipient detachment of the tread can be detected as a bulge in the tyre during the preflight check. This incipient detachment of the tread can also be detected on the sidewall of the tyre by a more detailed technical daily check or preflight check if the incipient detachment of the tread happens to be at the bottom of tyre after parking the aircraft.

This raises questions about the performance of the technical daily checks as well as the preflight checks.

2.2.2 Overloaded tyre 1:

Tyre 1 had a pressure of 192 psi after the incident flight. According to the daily check, this value was above the minimum value of 190 psi.

Wear marks were found on the margins of the tread, which were further apart than the distances found with numerous similar tyres of the same size. This can be explained by the fact that this tyre had to support the complete load of the left main landing gear after the loss of pressure of the right-hand tyre. The load was so great that this tyre was not permissible for further use any more. Other consequences of the high load are cracks found on the inside and outside shoulders of the inner liner.

2.2.3. Rim, valve stem and O-ring of the damaged tyre 2:

The last specified replacement of the O-ring as well as unscrewing of the valve stem and testing and tightening to the specified torque was due during the overhaul of the rim parts on 2.2.2008. That the O-ring was damaged with a resulting leak during this overhaul can be discounted, because the work was too far in the past for any leaks to have gone unnoticed.

The inspections after the incident showed that the unsecured valve stem could be unscrewed manually. The O-ring under the valve stem was broken, brittle, virtually ungreased and contaminated on its outside, probably with brake dust.

Because the O-ring was porous, probably due to ageing, it can be concluded that the O-ring was not replaced when the tyre was mounted. This is contradictory to the statements of the company regarding the alleged replacement of the O-ring when the tyre was replaced on 11.7.2008.

If an O-ring breaks, this loosens the valve stem, even if it was correctly tightened beforehand.

When the valve stem is tightened, the O-ring should be greased and placed in the circular slot in the rim, and it should not be damaged during installation. Inadequately greased O-rings may tear or be seriously damaged when the valve stem is tightened so they tear under the loads experienced during operation.

During the specified leak tests preceding operation the tyre is not moved or placed under load or heat stress, so it is possible that the valve will remain tight to a greater or lesser extent even if the O-ring is damaged or torn.

It is very probable that the valve stem was actually removed during mounting of the tyre, as stated by the manufacturer, and that the subsequent leak was the result of damage or tearing of the old O-ring with very little grease when the valve stem was re-tightened. It is not known whether the damage was caused by the porosity, the lack of grease on the O-ring or an incorrect tightening torque or a combination of all these factors.

If an O-ring is torn, the tyre will steadily lose pressure.

2.2.4. Tyre pressure of damaged tyre 2:

On the day of the incident, the daily check at 02:00 UTC found a pressure of 200 psi on all four main landing gear tyres, which is equivalent to the specified pressure. This was confirmed by the signature of an appropriately qualified person with no comment about leakage in the Flight Report Book (see 1.16.1).

This result is not credible for three reasons:

First, the specified pressure to which the main landing gear tyres should be inflated during the daily check is 200 psi. However, because this alleged check took place about 24 hours after the previous daily check and five flights were completed in this period, it would have been expected that the pressure would have been significantly lower than the specified setting because of diffusion, as is normal in commercial aircraft tyres.

Second, it is known that the pressure falls at different rates in different tyres.

Third, it is very probable that the pressure in tyre 2 had dropped well below the allowable tolerance at the time of the daily check because of the known status of the O-ring.

It can therefore be assumed that the tyre pressure was not checked during this daily check.

2.2.5. Tightening of the valve stem:

Neither the rim nor the valve stem have a hole that could have been used to secure the valve stem with wire. No residues of thread-locking compound were found on the valve stems of the main landing gear wheels. It is clear that technical devices for locking the valve stem were not used with the rim, nor was any other locking method used that did not require technical devices.

2.2.6. Other cases involving loose valve stems:

The company states that a number of loose valve stems have been found as a result of unsecured valve stems in the maintenance department.

This demonstrates the basic problem: unsecured valve stems can come loose.

2.2.7. The indicator system for the left main landing gear:

After the tread of tyre 2 had detached, the parts that flew off disconnected the electrical components of the proximity switch in the left engine intake. This caused the green locking indication for the left landing gear in the cockpit to go out, although at this point the landing gear was extended and locked. As a consequence, the locked status of the retracted left landing gear could be displayed but not the locked status of the extended landing gear.

2.2.8. Position of the engines:

Because the engines of this particular type of aircraft are placed immediately adjacent to the fuselage, detached parts of the tyres can be thrown into the engines.

2.2.9. Skids on the landing gear doors:

The skids on the left inboard landing gear door were more worn than the right-hand skids, and the left-hand skid was also broken. It is possible that the sizes of the two skids were selected with the assumption that they would wear evenly. Skids on landing gear doors that break in the event of extended ground contact may also cause serious damage because of bits that break off, e.g. damage to an engine behind the skid.

2.2.10. Deferred items as per Minimum Equipment List (MEL):

The right-hand reverse thrust and auto brake were non-functional.

Shutting down the left engine meant that the left reverse thrust was not available.

Auto brake is designed to reduce the pilot's work, and in addition the braking power can be set before use. The automatic braking process means that the speed is reduced very evenly, which also reduces tyre wear. Such an even braking process would be virtually impossible using manual braking. Without auto brake, the load on the previously damaged tyre 2 and tyre 1, which was now subject to the full load on the left side, was increased even more during landing.

The deferred items according MEL increased the stress on the pilots during the incident flight, also the probability of additional damage to damaged tyre 2 and to tyre

1, which was subject to the overload, and thus the possibility of the aircraft slewing to the side during landing.

2.3. Probable sequence:

The valve stem was removed before the last time rim 2 was assembled on 11.7.2008. When the valve stem was re-installed, the O-ring was not replaced or correctly greased. It was either damaged or completely torn while tightening the valve stem. No detectable pressure drop was found in the following pressure test. The mechanical and thermal operating stresses during subsequent take-offs and landings, which were increased by the failure of auto brake, accelerated the pressure drop.

The daily check on 31.7.2008 did not detect any pressure drop in tyre 2, although it is probable then that the pressure had actually dropped. The incipient detachment of the tyre tread was not noticed during the preflight checks, particularly the checks before the incident flight.

The pressure drop resulted in the tyre flexing and the tread starting to detach.

The tread on tyre 2 finally became detached during the take-off run at Vienna Schwechat airport, which resulted in the partial breakage of the water deflector between tyres 1 and 2 and broke the electrical connection of the electrical components of the proximity switch for the left landing gear. Two pieces of tyre penetrated the left landing flap, other pieces were thrown as far as the left engine, where they remained in the inlet area or were sucked in to the engine and burnt, which caused serious damage to the engine. The burning of the tyre pieces generated the burning smell that penetrated the air supply of the air-conditioning system and thus the cockpit.

The oval fracture lines found on the damaged tyre 2 were created before detachment of the tread during take-off on runway 29, and the oval imprints were created when the deflated tyre touched down during relanding on runway 34.

2.4. Visual inspection of commercial aircraft during flight:

Large parts of commercial aircraft (e.g. including the landing gear, control surfaces, engines etc.) cannot be visually inspected in full during flight from the cockpit or the passenger cabin.

For example, damage can occur in very different forms and can also be very difficult to assess, particularly if the exact cause of the damage is unknown, as was the case with the aircraft involved in this incident. Even redundant sensors at different positions often show only limited information and may fail and become faulty indicators, as was the case in this incident with the secondary damage to the locking indicator of the left landing gear.

In this serious incident the cause of the incident and the general status of the landing gear or the left-hand engine were not known to the pilots until after the aircraft had landed. When the power dropped and the engine started to vibrate, an appropriately positioned monitoring camera could have shown the left piece of tyre tread in the intake area of the engine. This would not only have enabled quick conclusions regarding a major cause of the power loss and the vibration in the engine but would also have shown the cause of the engine fault. The cause of the burning smell in the cockpit would also have been clear, because the layout of the engines in this type of aircraft would have allowed the assumption that if the tread of a tyre detached, parts of the tyre could enter the engine and be burnt there.

Shutting down one engine in flight on an aircraft with only two engines is a serious decision. On the one hand, if it is necessary to shut down, it should be done without delay; on the other hand, an engine should only be shut down if it is absolutely necessary. Even a damaged engine can still supply urgently required power. Because engines are not only a means of propulsion but also generally power the pneumatic, hydraulic and electrical systems, shutting down an engine means that the advantage of redundancy in the system with both engines operating is completely given up.

Shutting down one engine also has additional consequences that are not immediately apparent at first glance: For example, TCAS Resolution Advisories, which recommend climbing if there is danger of collision, are no longer applicable, because the climbing capacity of the aircraft after shutting down one engine is so low that the advisories cannot be followed.

To make a sensible decision on whether or not to shut an engine down, the pilots must be given as much information as quickly as possible on all aspects of a fault. One source of information would be live camera images, which however were not available to the pilots.

If such images had been available to the pilots, they may have decided against shutting down the left engine, because a major cause of the power loss and vibration was the large piece of tyre in the intake area of the engine, and an immediate additional power loss or increased vibration was therefore unlikely. If the left engine had continued running, the pilots would also have had an additional, though limited, power reserve available to them. The left engine would also have remained available to supply power for the pneumatic, hydraulic and electrical systems and the left reverse thrust would have been available.

In his comment to the draft of this incident report, the pilot noted that the pneumatic, hydraulic and electrical systems were no longer available after shutting down the left engine, but they were also not required during the remainder of the flight. Here it must be noted that redundancy is not only justified if it is actually needed.

Shutting down the left engine had the following effects on the remainder of the flight:

- No power reserve from the left engine was available.

  This could, for example, have further reduced the options of the pilots if they had needed to avoid an obstacle, if the remaining engine had failed or if they had to abort relanding and go around.

- The left thrust reverser was no longer available.

  Because the right thrust reverser had already failed, no thrust reverser at all was available. This extended the landing distance.

- The supplementary generators of the left engine were not available as an additional redundant system.

A monitoring camera viewing the landing gear could have allowed the pilots to assess the general status in much more detail than by observation from the ground. This would have made it unnecessary to make low overflights below the circling minimum descent altitude and below minimum radar altitude with a high flight mass and only one operating engine followed by climbing with minimal climbing capacity, which required visual avoidance of obstacles.

Striking was the number of individual factors that made this serious incident and the resulting risks possible.

3 Conclusions

3.1 Findings

- The requirements for operation of the aircraft in flight had been met at the time of the incident.
- The pilots had the required authorisations to operate the flight. They had sufficient flying experience.
- The weather had no noticeable influence on the incident.
- Only parts of the left main landing gear were found in the search on runway 29.
- It is not possible to visually inspect large parts of the aircraft (e.g. landing gear, engine, control surfaces) from the cockpit or passenger cabin during flight.
- It is also not possible to see from the ground if the main landing gear is locked whether extended or retracted.
- The precautionary use of a foam carpet for an emergency landing is not used internationally anymore, because it is no longer state of the art of emergency measures.
- The tyre tests conducted by the manufacturer showed that the loss of the tread of tyre 2 can only be explained by a loss of pressure.
- The manufacturer's tests showed that tyre 2 remained tight in spite of losing the tread.
- The valve stem of tyre 2 was not secured. Securing the valve stem was not specified or required.
- After landing, the valve stem was found to be only hand-tight, and the O-ring beneath it was porous and broken.
- The last check of the tightening torque of the valve stem on rim 2 was specified on 2.2.2008 during the overhaul of rim 2.
- When the right-hand tyre was mounted on the rim, the correct installation of the valves was required to be checked by visual inspection, but not the disassembly or assembly of the valve stem nor the tightening torque or the replacement of the O-ring.
- However, according to the company, the O-ring is replaced every time the tyre is replaced and the torque of the valve stem is also checked at this time. However a work card and quality assurance of the completion of this work are not specified. These statements of the company therefore cannot be confirmed.

3.2 Probable causes

- Disconnection of the electrical components of the proximity switch of the left main landing gear indicator in the left-hand main landing gear well by foreign parts.
- Penetration of foreign parts into the left-hand engine.

Probable contributing factors:

- Valve stem fastening to rim 2 not secured.
- Lack of clarity from the company about the additional maintenance work performed in the area of the valve stem when the tyre was replaced.
- Use of a porous O-ring for the valve stem on rim 2.
- Inadequate greasing of the O-ring of the valve stem on rim 2.
- The daily check of tyre 2 on the day of the incident did not detect any pressure drop, as it can be assumed that the tyre pressure was not checked at all.

- Signs of the tread becoming detached on tyre 2 were not recognised during the preflight checks.

Possible contributing factors:

- Incorrect tightening torque used when fastening the valve stem to rim 2 when the tyre was replaced on 11.7.2008.

4a Safety recommendations

EASA, FAA, aircraft manufacturer:

SE/SUB/ZLF/5/2013:
Securing valve stems on landing gear tyres of commercial aircraft:
The valve stems on the landing gear tyres were not secured on this aircraft. A means of securing was also not specified. Because it was not secured, the valve stem of tyre 2 could come loose after the O-ring was damaged. This ultimately resulted in serious damage to the aircraft and flight situations with increased risk.
Certification requirements for commercial aircraft should therefore be revised to specify that the valve stems on the landing gear tyres of commercial aircraft should be effectively secured (e.g. with thread locker or wire)

SE/SUB/ZLF/6/2013:
Include all observation and inspection options in checklists for emergency procedures:
In this aircraft the pilots had the option of visually verifying the locking mechanism of both sets of main landing gear when extended during flight from the floor of the passenger cabin with a periscope. The pilots did this in this incident, because the company emergency procedure checklist for "Abnormal Gear Indication with the Handle Down" listed this option. The aircraft manufacturer's checklist did not list this option.
The emergency checklists in commercial aircraft should list all available options for observation and control of components during flight.

SE/SUB/ZLF/7/2013:
Visual inspection of commercial aircraft during flight:
During flight pilots are faced with the problem, as in this serious incident, that they can be confronted with faults, damage and emergencies without having sufficient information about the status of the parts or components involved, because they are only partly or not visible at all from the cockpit or passenger cabin. This means they lack the information required to make quick and correct decisions. Sensors installed at various locations often only provide specific information and, as in this incident, where the locking indicator for the left landing gear gave incorrect information because of damage, this resulted in additional ambiguities and resulting problems. The inability to visually check the engines and landing gear meant that the pilots could not make the most useful decisions and this also led to flight situations with an increased risk.
The certification requirements for commercial aircraft should be revised to allow pilots the option of visual inspection of at least the most important parts of the aircraft (e.g, landing gear, engines, main control surfaces) during flight.

EASA, FAA:

SE/SUB/ZLF/8/2013:
Supplement to Certification Specifications 25 (CS-25), pressure displays of landing gear tyres:
Insufficient pressure in landing gear tyres can, as happened in this serious incident, cause massive damage to the aircraft and result in flight situations with increased risk.
On this topic also see, for example, the accident report issued by the US National Transportation Safety Board (NTSB)
http://www.ntsb.gov/doclib/reports/2010/AAR1002.pdf.
CS-25 should be revised to specify installation of pressure indicators for all landing gear tyres in the cockpit of commercial aircraft.

EASA:

SE/SUB/ZLF/9/2013:
Revision of training, education and advanced education of pilots of commercial aviation to intensify attention with aspects of the occurrence of various incidents.
In this serious incident, two different incidents occurred as a result of a single event, and the response to them resulted in flight situations with an increased risk.
Pilots face the problem of developing the best response to the simultaneous occurrence of different incidents. The occurrence of two incidents, each of which could be systematically managed separately without difficulty, can in combination lead to completely different risks and required actions. Therefore, actions required by different emergency procedures may be contradictory. The best possible solution for a multiple incident scenario cannot simply be to apply procedure for the first incident applied to the second incident, but would be a different view that recognises the overall problem and takes all aspects into account. It is not sufficient simply to process the checklists in sequence to deal with multiple incidents. This means that persons dealing with the incident must be open to changes in plans.
Training, education and advanced education of pilots should be revised to the effect of improving responses to aspects of the occurrence of various incidents. (For example, this could involve increased theoretical education, training and improvement of awareness.)

SE/SUB/ZLF/10/2013:
Development of processes that ensure that the daily technical checks and preflight checks of commercial aircraft are correctly performed.
In this serious incident, measurable and visible defects on the aircraft were not detected by the daily technical and preflight checks. The consequence was that the defects caused serious damage to the aircraft and resulted in flight situations with increased risk.
EASA should initiate action to ensure that the daily technical checks and the preflight checks of commercial aircraft are correctly performed.

Operator of the aircraft:

SE/SUB/ZLF/11/2013:
Specify maintenance work with a work card and quality assurance of the completed work:
The aircraft manufacturer did not specify any maintenance work in the area of the valve stem during a tyre replacement for this aircraft. According to the company, the valve stem is always removed and the O-ring is always replaced when the tyre is replaced. However, a work card was never prepared. This means that the scope of the work is not defined, and there is no confirmation of the additional work or any quality assurance of the completed work.
Maintenance work should always be specified with a work card and the completed work should always be subject to a quality assessment.

Austro Control GmbH, Austrian airports:

SE/SUB/ZLF/12/2013:
Flight paths and flight areas for low overflights by commercial aircraft in the area of airports:
In this serious incident, a twin-engine MD 88, one of whose engines had been shut down by the pilots because of technical problems performed two low overflights at about 500 and 400 ft AGL north of the control tower at about 300° to allow the air traffic controllers to observe the status of one of the two main landing gear sets, which also had a technical fault. During the low overflights, the aircraft flew over several buildings, a tank farm and other facilities, including a scarcely visible mobile phone lattice mast at 735 ft MSL. The pilots decided to make the first low overflight at very short notice, which means that it is questionable whether they were aware of the obstacles. The initial climb after the second low overflight was conducted shortly before a chemical plant and the adjacent Schwechat refinery.
If commercial aircraft are performing low overflights in the region of airports, Austro Control GmbH should in cooperation with Austrian airports define flight paths and/or flight areas that will minimise the risks involved (e.g. routes and areas with the least number of obstacles before, during and after the low overflight, e.g. along runways or runway extensions). Personnel on the ground should select positions from which they can get the best possible view (e.g. directly under the aircraft when checking the landing gear).

4b Actions that have been taken or announced resulting from consultation based on safety recommendations planned by SUB/ZLF:

In the consultation the Flughafen Wien AG has announced based on the planned SE/SUB/ZLF/12/2013:

" [We] … will include a section for overflights in the next VIE-ACG agreement, … , that airport operations managers organise the ground crew (technicians - if available) and bring them to the runway for observation."

In the course of consultation Austro Control GmbH has announced based on the planned SE/SUB/ZLF/12/2013:

"To minimise the risk of low clearance distances to obstacles that are difficult to see in the area of the airport, ACG/TWR Wien will in future allow overflights - for the purpose of observation by technically qualified personnel at the edge of the runway - in case of emergency only in the area of the runways in conformity with the published approach procedures. This procedure will be included in the ACG/VIE agreement at the next update."

Vienna, 16.10.2013
Federal Office for Transport
Austrian Civil Aviation Safety Investigation Authority

Attachments:

1. CONSULTATION:

A consultation was conducted in accordance with Sec. 14 of the Austrian Accident Investigation Act in the current version. The draft of this incident report has been submitted to
- the Austrian civil aviation authority in the Austrian Ministry for Transport, Innovation and Technology,Vienna
- Austro Control GmbH, Vienna
- Flughafen Wien A.G.,
- the Bridgestone Company in Frameries, Belgium,
- the Boeing Company in Seattle, Washington, USA,
- the National Transportation Safety Board, Washington D.C., USA,
- the Comision des Investigation de Accidentes e Incidentes de Aviation Civil, Madrid, Spain,
- the operator of the aircraft in Madrid,Spain.

The above parties had the opportunity to comment on the draft of the incident report.

1A: COMMENTS:

- No comment was received from the Bridgestone Company in Frameries, Belgium.

- The Austrian Civil Aviation Authority in the Austrian Ministry for Transport, Innovation and Technology sent a blank message.

- The comments submitted by the National Transportation Safety Board, Washington D.C., USA, The Boeing Company, USA, and Flughafen Wien A.G. have been included in the incident report.

- The comment by Austro Control GmbH could partly be included in the incident report.

- The major part of the comment of the crew sent by the Spanish safety investigation authority, the Comision des Investigation de Accidentes e Incidentes de Aviation Civil, Madrid, Spain, could be included in the incident report.

- Where relevant, some parts of the comments of the operator of the aircraft also sent by the Spanish safety investigation authority, the Comision des Investigation de Accidentes e Incidentes de Aviation Civil, Madrid, Spain, were included in the incident report.

1B: COMMENTS THAT WERE NOT INCLUDED:

Some individual, relevant parts of the comments submitted to the Austrian Civil Aviation Safety Investigation Authority, taking into account available data, information and subsequent detailed testing could not or only partially be followed in this incident report and have therefore not been included in the incident report. These parts of the comments are appended to the report below, as planned:

Crew:

…

„- …Obviously, the nearest () airport was that of Vienna (LOWW) …"

"…the suggestion of a possible landing at the airport in Bratislava, which is approx. 30 NM away and has 15 m. wider runway, is not appropriate as it might entail the risk of getting the only operative engine stalled on the way to that airport."

"…"

Operator of the aircraft:

"We consider that a tyre with a total 276 life cycles and the last 10 of them with a new tread (retread level 1) should not have failed after so few cycles (1-5), not even under conditions of total pressure loss."

"… we observe that in Photo 2 of the Bridgestone report there are two well recognizable pieces of tread with a clean and straight border, which might be a sign of a very quick and cut-like separation occurred in that zone of the tread."

"- As the point of origin of the tread detachment was easily recognizable (concentric fatigue-like marks), and no leaks were found in the carcass of the tyre in the same zone, we are currently inclined to think that the starting point of this detachment might correspond to a bump or cut with an object on the runway or to a defect on the tread. At this stage, these possibilities seem more plausible to us than merely a 1 to 5 cycles no-load operation with a complete pressure loss.

…"

Austro Control Gmbh:

"…"

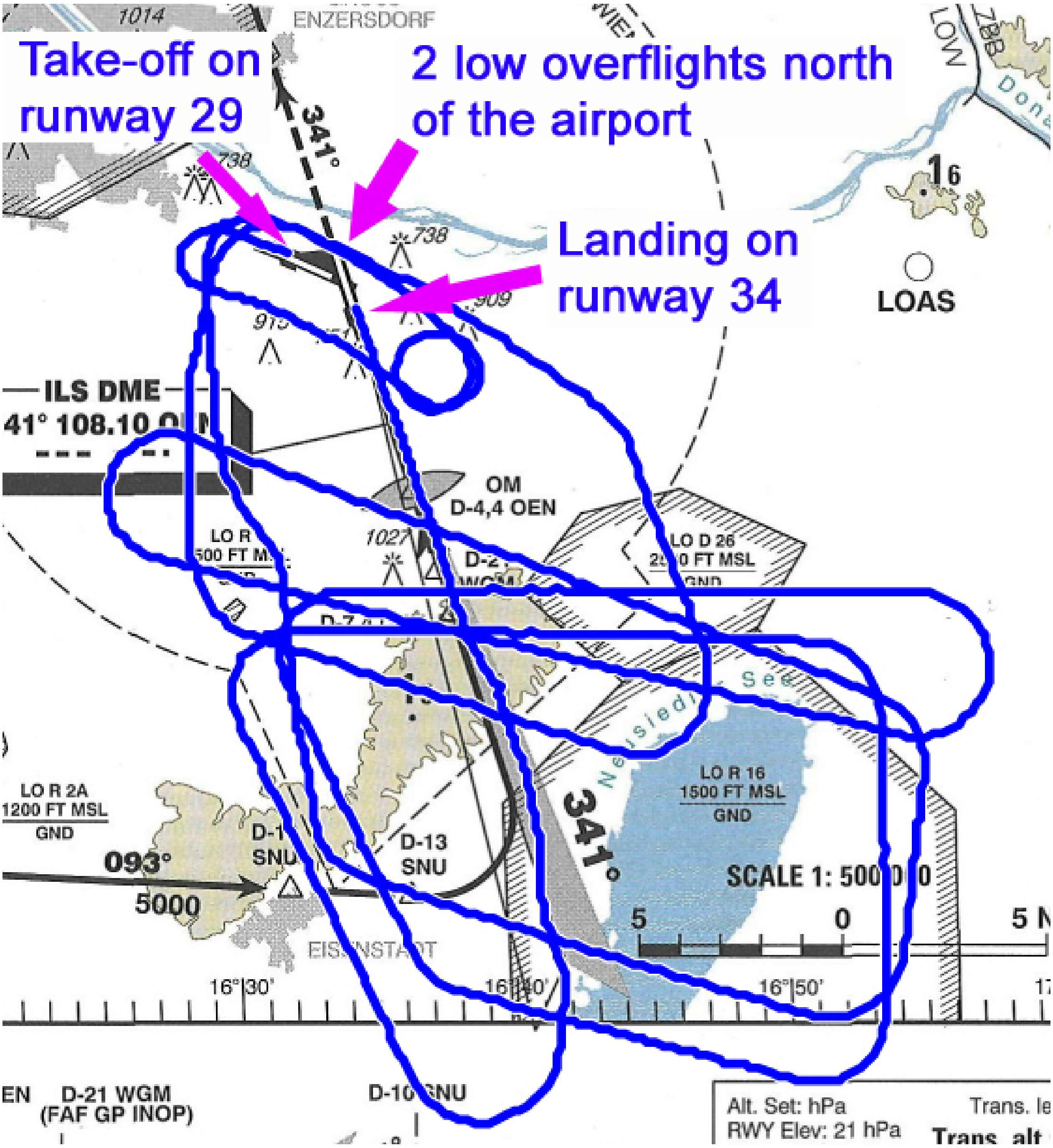
"2. *His* (comment by SUB/ZLF: statement by the air traffic controller) *statement was rather that he did not know whether a qualified technician would have been available, because no MD80 series aircraft are based at Schwechat airport.*"

"…"

The lattice masts that were to have been overflown at 200 ft cannot be confirmed to have been in the area where the overflights took place.

…"

2. Map:



Map: Flight path of the incident flight

3. EASA Safety Information Bulletin SIB No: 2013-10

This is information only. Recommendations are not mandatory. TE.CAP.00117-003 1/2 Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

EASA Safety Information Bulletin
SIB No.: 2013-10
Issued: 10 July 2013
Subject: Properly Inflated Aircraft Tyres
Ref. Publications: Federal Aviation Administration (FAA) Safety Alert for Operators (SAFO) 11001 dated 06 January 2011.
Applicability: All aircraft fitted with inflatable tyres.
Description: The FAA have published the above-referenced advisory document (which can be accessed by the hyperlink above) to advise aircraft owners and operators of an operational safety concern, stressing the importance of ensuring properly inflated tyres and pointing out the potential consequences which improper tyre pressure can have on the performance of aircraft operations during Taxi, Take-off and Landing.
After reviewing the available information, EASA support the recommended actions contained in FAA SAFO 11001. Specifically, to ensure appropriate personnel are made aware of:
- The importance of proper tyre pressures,
- Appropriately calibrated tyre pressure gauges and
- servicing safety precautions.
- Maintenance manual tyre pressure interval checks

Failure to follow the published procedures with aircraft tyres could have serious safety consequences.
Since EASA considers this to be a ‘generic’ safety subject that should apply to all aircraft equipped with inflatable tyres, i.e. including helicopters, and not limited to aircraft of U.S. origin, the SAFO cannot be considered as a ‘State of Design’ advisory. For that reason, EASA have decided to explicitly apply these recommendations to all aircraft equipped with inflatable tyres. This SIB is published to ensure that all affected aircraft owners and operators are made aware of the FAA safety recommendations, now endorsed by EASA.
At this time, the safety concern described in this SIB is not considered to be an unsafe condition that would warrant Airworthiness Directive (AD) action under EU 748/2012, Part 21.A.3B. EASA SIB No: 2013-10.
This is information only. Recommendations are not mandatory. TE.CAP.00117-003 2/2 Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet.

Contact: For further information contact the Safety Information Section, Executive Directorate, EASA. E-mail: ADs@easa.europa.eu.