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GENERAL CIVIL AVIATION AUTHORITY

United Arab Emirates

Air Accident Investigation Sector

Incident

- Final Report -

AAIS Case Nº: AIFN/0008/2017

Tire Failure Resulting in Loss of a Single Hydraulic System

Operator:	flydubai
Make and Model:	Boeing B737-800
Nationality and Registration:	The United Arab Emirates, A6-FDS
Place of Occurrence:	Dubai International Airport
State of Occurrence:	United Arab Emirates
Date of Occurrence:	8 August 2017

GENERAL CIVIL AVIATION AUTHORITY

Air Accident Investigation Sector
General Civil Aviation Authority
The United Arab Emirates

Incident Brief

AAIS Case Nº:	AIFN/0008/2017
Operator:	flydubai
Aircraft make and model:	Boeing B737-800
Registration mark:	A6-FDS
Manufacturer serial number:	40246
Number and type of engines:	Two, CFM56-7B Turbofan engines
Date and time (UTC):	8 August 2017, 0716
Location:	Dubai International Airport, the United Arab Emirates
Category:	Transport (Passenger)
Persons on-board:	35
Injuries:	Nil

Investigation Objective

This Investigation was conducted by the Air Accident Investigation Sector (AAIS) pursuant to the United Arab Emirates (UAE) *Federal Act No. 20 of 1991*, promulgating the *Civil Aviation Law, Chapter VII – Aircraft Accidents*, Article 48. It complies with the UAE *Civil Aviation Regulations (CARs), Part VI, Chapter 3*, in conformity with *Annex 13 to the Convention on International Civil Aviation*, and in adherence to the *Air Accidents and Incidents Investigation Manual*.

The sole objective of this Investigation is to prevent aircraft accidents and incidents. It is not the purpose of this activity to apportion blame or determine liability.

This Final Report is structured according to the format contained in *Annex 13* to serve the purpose of this Investigation. The information contained in this Report is derived from the data collected during the Investigation of the Incident.

This Final Report is made public at:

http://www.gcaa.gov.ae/en/epublication/pages/investigationReport.aspx

Investigation Process

The occurrence involved a Boeing 737-800 aircraft, registration A6-FDS, and was notified to the AAIS by phone call to the Duty Investigator (DI) Hotline Number +971 50 641 4667.

After the Initial/On-Site Investigation phase, the occurrence was classified as an 'Incident'.

The scope of the Investigation into this Incident is limited to the events leading up to the occurrence; no in-depth analysis of non-contributing factors or non-safety related issues was undertaken.

Notes:

1 Whenever the following words are mentioned in this Report with the first letter Capitalized, they shall mean the following:

- (Incident) – this investigated incident referred to on the title page of this report
- (Aircraft) – the aircraft involved in this incident
- (Investigation) – the investigation into the circumstances of this incident
- (Operator) – flydubai (operator of the aircraft)
- (Report) – this incident Final Report.
- (Commander) – the commander of the incident flight
- (Co-pilot) – the co-pilot of the incident flight

2 Unless otherwise mentioned, all times in this Report are 24-hour clock in Coordinated Universal Time (UTC), (UAE Local Time minus 4).

3 Photos and figures used in the text of this Report are taken from different sources and are adjusted from the original for the sole purpose to improve clarity of the Report. Modifications to images used in this Report are limited to cropping, magnification, file compression, or enhancement of colour, brightness, contrast or insertion of text boxes, arrows or lines.

Abbreviations

AAIS	The Air Accident Investigation Sector
ADD	Acceptable deferred defect
AFM	*Airplane flight manual*
ALT	Alternate
ALT	Altitude
AMM	*Aircraft maintenance manual*
AOC	Air operator certificate
ARC	Airworthiness review certificate
ATC	Air traffic controller
ATPL	Air transport pilot license
CAR	*Civil Aviation Regulations* of the United Arab Emirates
CAT	Category
CMM	*Cabin maintenance manual*
CONT	Control
CONT	Continuous
CVR	Cockpit voice recorder
DFDR	Digital flight data recorder
DN	Down
ELEC	Electrical
ELP	English language proficiency
EMDP	Electric motor-driven pump
ENG	Engine
EXT	Extended
FAA	The Federal Aviation Administration of the United States
FCOM	*Flight crew operations manual*
FCTM	*Flight crew training manual*
FLT	Flight
FMA	Flight mode annunciation
FMS	Flight management system
FOD	Foreign object debris
Ft	Feet
GCAA	The General Civil Aviation Authority of the United Arab Emirates
G/S	Glideslope
HYD	Hydraulic
ICAO	International Civil Aviation Organisation

ILS	Instrument landing system
Kt	Knot
LE	Leading edge
mbar	millibar
M/E	Multiple engines
MHz	Megahertz
NCC	Network control center
No.	Number
OM	*Operations manual*
PF	Pilot flying
PM	Pilot monitoring
PTU	Power transfer unit
QRH	*Quick reference handbook*
RUD	Rudder
SEP	*Safety equipment procedures*
SID	Standard instrument departure
SOP	*Standard operating procedure*
STBY	Standby
UAE	The United Arab Emirates
UTC	Coordinated Universal Time
V_R	Rotation speed

Synopsis

On 8 August 2017, a flydubai Boeing B737-800, registration mark A6-FDS, operated a scheduled passenger flight FZ081, from Dubai International Airport (OMDB) to Bahrain International Airport (OBBI). There were a total of 35 persons on-board the Aircraft: 29 passengers, two flight crewmembers, and four cabin crewmembers.

The Aircraft lined up on runway 12R for departure, and after take-off clearance was given, the flight crewmembers commenced the takeoff.

After the Aircraft lifted off the runway, the landing gear was retracted, and at about 250 feet radio altitude while climbing, the Aircraft experienced a pressure loss of Hydraulic System A. The Aircraft continued climbing to the pre-selected altitude of 4,000 feet.

The flight crew contacted ATC Departure declaring that the Aircraft had suffered an hydraulic system problem, and requested to go to the hold for troubleshooting. The Aircraft entered the hold at the GINLA waypoint as advised by the Controller.

The flight crew executed the required checklists, including the non-normal checklist for loss of hydraulic system A, and decided to return to OMDB. The flight crew requested vectoring for the approach and landed safely on runway 12L. After vacating the runway via taxiway N8, the Aircraft taxied to parking stand E23.

The Air Accident Investigation Sector determines that the cause of the Incident was the rotation of the damaged No. 1 tire inside the left main wheel well that consequently caused damage to some components and lines of hydraulic system A, and the subsequent hydraulic system A pressure loss.

The Air Accident Investigation Sector identifies the contributing factors to the Incident as follows:

- The intermittent operation of the left alternate antiskid valve, which most probably allowed the two wheels of the left main landing gear to enter the wheel well while still spinning.
- The rotating wheel peeled portion of the center tire tread rib of the number 1 wheel did not operate the frangible fitting, resulted in a continuation of the left gear retraction, allowing the number 1 tire peeled portion to damage the hydraulic system A and other parts located in the vicinity.

In this Final Report, the AAIS issued two safety recommendations addressed to the Operator, one to the General Civil Aviation Authority (GCAA), and one to the Aircraft manufacturer.

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1. Factual Information

1.1 History of Flight

On 8 August 2017, a flydubai Boeing B737-800, registration mark A6-FDS, operated a scheduled passenger flight FZ081, from Dubai International Airport (OMDB[1]) to Bahrain International Airport (OBBI[2]). There were a total of 35 persons on-board the Aircraft: 29 passengers, two flight crewmembers, and four cabin crewmembers.

The Commander was the pilot flying (PF) and the Co-pilot was the pilot monitoring (PM).

The Aircraft was pushed back from its parking stand E23 at about 0646 UTC. A long pushback was instructed since there was another aircraft being pushed back on the lefthand side of the Aircraft on parking stand E22. Taxi instructions were given to the flight crewmembers for a departure from runway 12R. The Aircraft was planned for a standard instrument departure runway 12R, via SITAT 2G.

Before the departure, the flight crewmembers selected flaps 1. The take-off weight was approximately 54.6 tons, and the calculated rotation speed (V_R) was 134 knots. The flight crew set the selected altitude to 4,000 feet (ft) as per OMDB standard instrument departure (SID).

The Aircraft lined up on runway 12R for departure at about 0713. After take-off clearance was given, the flight crewmembers commenced the takeoff at about 0715.

After the Aircraft lifted off the runway, the landing gear was selected up, and at about 250 ft radio altitude while climbing, the Aircraft experienced a loss of hydraulic system A, at 0716:35. The Aircraft continued climbing to the selected altitude.

At 0716:55, Dubai air traffic Controller (ATC) Tower instructed the Aircraft to change to Dubai ATC Departure on frequency 121.025 MHz.

At 0717:18, when the Aircraft was just passing 1,450 feet radio altitude, the Co-pilot informed Departure that the Aircraft had a hydraulic system problem, and requested to go to a hold area that was convenient for ATC. Departure Controller instructed the flight crew to continue the climb as per the SID. The Co-pilot then requested to maintain altitude at 4,000 feet, which was approved by the Departure Controller.

The Departure Controller enquired whether the Aircraft could hold at GINLA, which was confirmed by the flight crew. Subsequently, at 0720:51, Departure Controller instructed the Aircraft to turn left and proceed directly to the GINLA waypoint, which was then performed by the flight crew. The Commander asked the Departure Controller for confirmation as to whether the Aircraft, at inbound GINLA, needed to turn right to enter the hold, which was confirmed by the Controller.

The flight crew executed the applicable checklists, including the non-normal checklist for loss of hydraulic system A.

At 0722:24, Departure asked the Aircraft an estimated time for holding at GINLA. The Commander responded that it will take a maximum of 10 minutes.

At 0724:25, the Commander informed the cabin crew about the loss of the hydraulic system, and the extended landing gear. He also informed the cabin crew that the Aircraft would return to Dubai as a precaution in about 10 minutes. Thereafter, the Commander contacted the Operator's network control center (NCC) and informed them that the Aircraft

[1] OMDB is the ICAO four letters airport code for Dubai International Airport
[2] OBBI is the ICAO four letters airport code for Bahrain International Airport

was at an altitude of 4,000 feet altitude about 30 nm from Dubai, had lost the hydraulic system A, and that the flight crew was planning to return to Dubai in 10 minutes.

At 0733:16, the flight crew contacted Departure, and informed the Controller that the Aircraft was ready for the approach to runway 12L and requested radar vectoring. The Departure Controller then provided the requested radar vectoring.

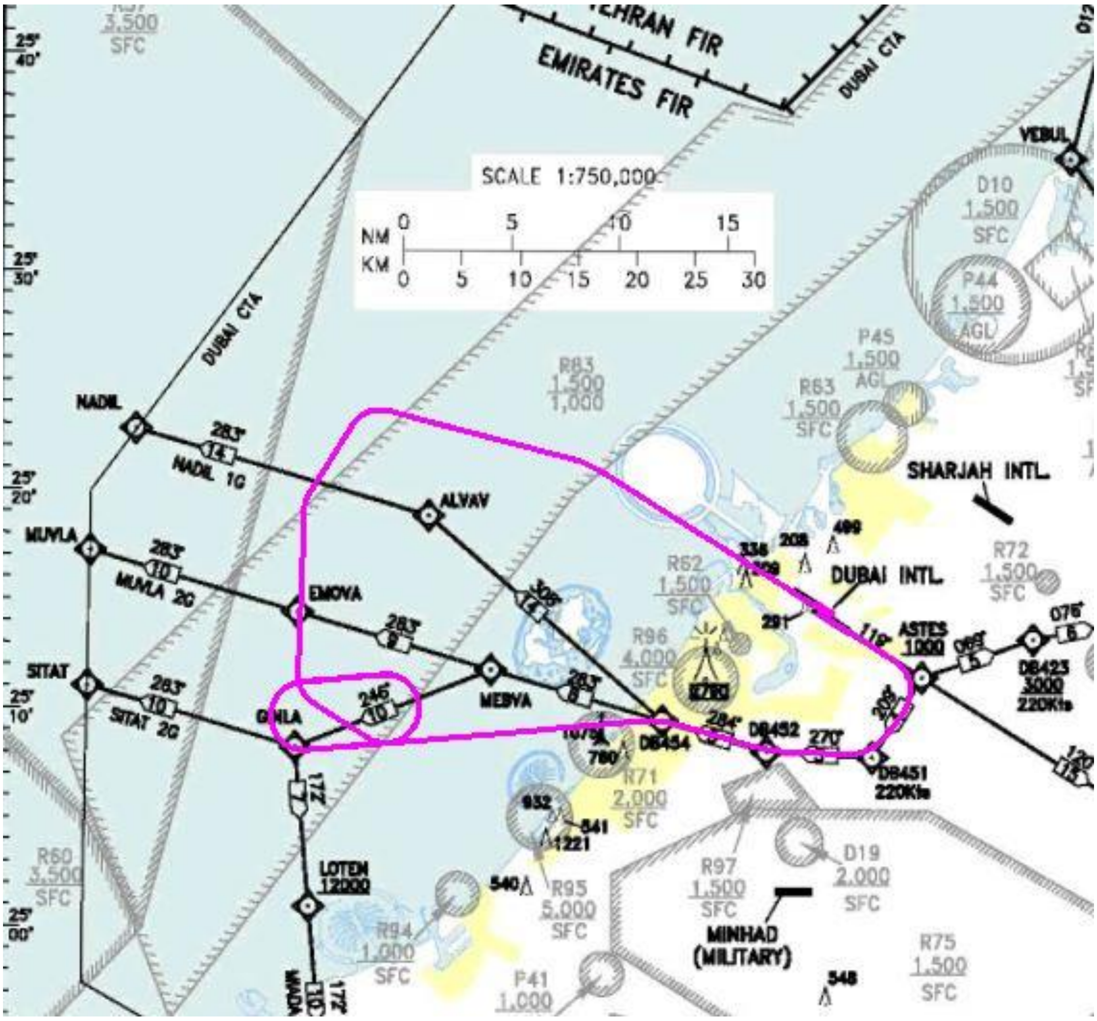

Figure 1. Flight path on RNAV 1[3] SID runway 12R chart

At 0734:26, Departure informed the flight crew about the runway to be used, which was 12L and the QNH of 1,000 mbar. The Commander replied correctly, and informed that he expected to have some hydraulic fluid on the runway, which was acknowledged by Departure.

At 0734:56, Departure vectored the Aircraft onto a heading of 360 degrees, and asked whether the flight crew were declaring an emergency. The Co-pilot acknowledged the instruction to take up a heading of 360 degrees, and he declared an emergency based on the decision of the Commander. The Departure Controller acknowledged the declaration of an emergency.

At 0735:19, Departure instructed the Aircraft to contact ATC Approach on frequency 127.9 MHz. The Aircraft then contacted Approach and informed the Approach Controller that they were at 4,000 feet on a heading of 360 degrees. The Approach Controller instructed the

[3] Aircraft operating on RNAV 1 STARs and SIDs must maintain a total system error of not more than 1 nautical mile for 95% of the total flight time. All pilots are expected to maintain route centerlines, as depicted by onboard lateral deviation indicators and/or flight guidance during all RNAV operations unless authorized to deviate by ATC or under emergency conditions. Cross-track error/deviation should be limited to 0.5 nautical mile. (Source: Jeppesen – Briefing Bulletin)

flight crew to maintain the same altitude and heading. Subsequently, the Controller provided radar vectoring for the approach, and instructed the flight crew to report when established on the ILS for runway 12L.

At 0737:35, the Aircraft turned right onto a heading of 030 as instructed by the Approach Controller.

At 0738:24, Approach instructed the Aircraft to descend to altitude 2,000 feet, and subsequently the Aircraft started to descend.

At 0738:55, Approach instructed the Aircraft to turn right to UKRIM waypoint for ILS runway 12L and to report when established, which was acknowledged correctly by the Co-pilot.

At 0739:45, the Aircraft contacted Approach and informed that the Aircraft was being slowed and that the flight crew would extend the gear manually. The Approach Controller enquired about the required speed on final, which the flight crew advised would be 140 knots.

The Commander contacted the NCC, and advised that the Aircraft would land within 5 minutes. He requested NCC to inform the Operator's maintenance department about the fluid quantity of hydraulic system A, which was zero, and the 10 psi system pressure. Subsequently, the flight crew completed the manual gear extension checklist.

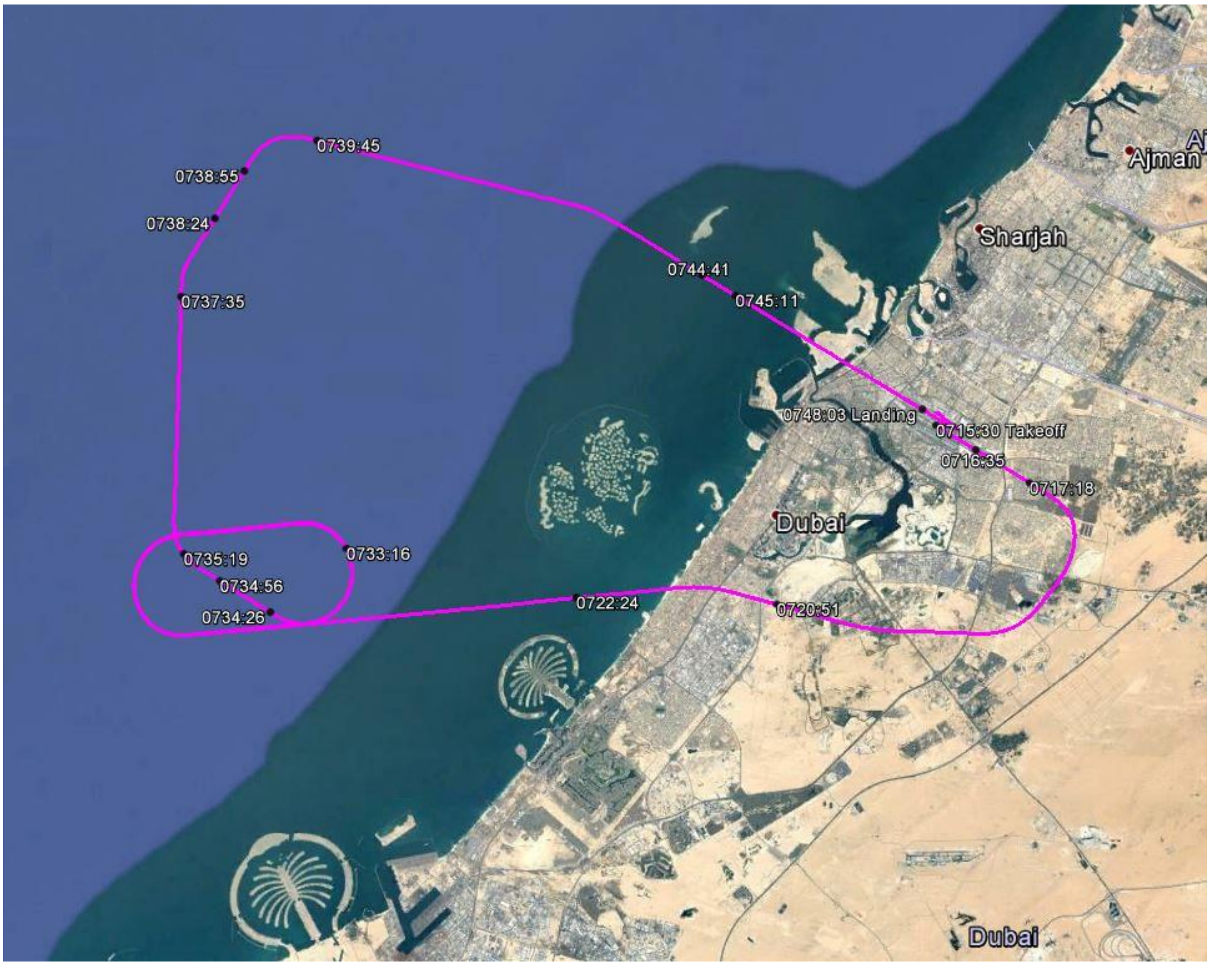

Figure 2. Flight path [Google Earth]

At 0744:41, Approach Controller asked the flight crew to confirm that the Aircraft was established on the glideslope. This was confirmed. Subsequently, Approach instructed the Aircraft to contact Dubai Tower on 118.75 MHz.

The Co-pilot contacted the Tower, at 0745:11, and confirmed that the Aircraft was fully established on the ILS for runway 12L, with a distance to go of 6.2 nautical miles. The Tower provided wind information, cleared the Aircraft to land, and informed the flight crew to vacate the runway at any exit on the left as required.

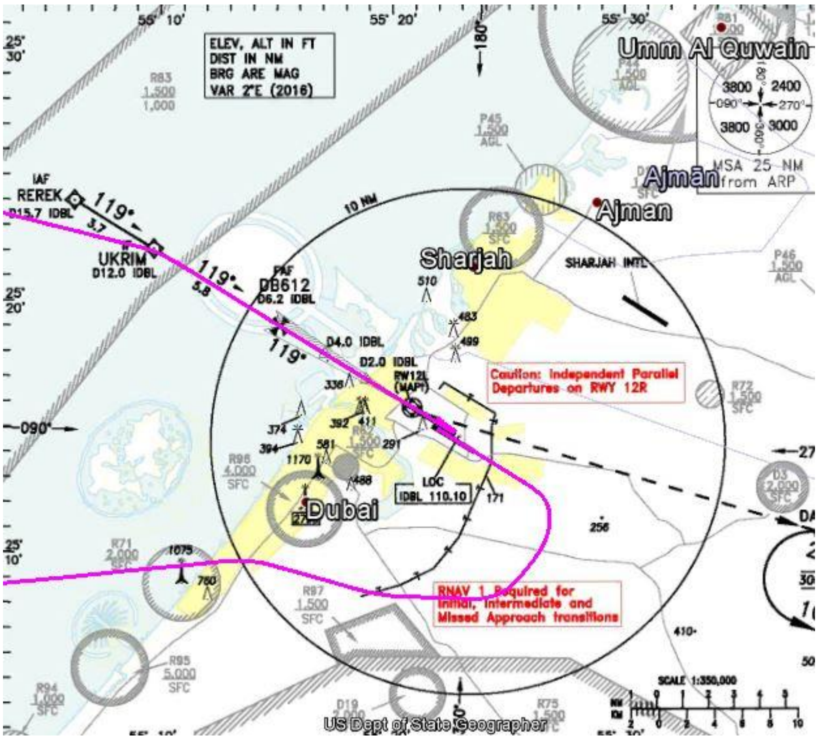

Figure 3. Flight path on ILS runway 12L chart

The Aircraft landed uneventfully on Runway 12L at 0748:03, vacated the runway via taxiway N8, and taxied to parking stand E23. The engines were shut down at 0757:47.

1.2 Injuries to Persons

There were no injuries to persons as a result of the Incident, as shown in Table 1.

Table 1. Injuries to persons

Injuries	Flight crew	Cabin crew	Other crew onboard	Passengers	Total onboard	Others
Fatal	0	0	0	0	0	0
Serious	0	0	0	0	0	0
Minor	0	0	0	0	0	0
None	2	4	0	29	35	0
TOTAL	**2**	**4**	**0**	**29**	**35**	**0**

1.3 Damage to Aircraft

After the landing, the Aircraft was inspected, and it was found that the No. 1 tire (left outboard tire) tread center rib had completely peeled from the tire. However, the tire was still inflated (figure 4).

Figure 4. Damaged No. 1 tire (left outboard tire)

The Aircraft sustained damage to the APU fuel drain line, landing gear and hydraulic parts (see Appendix 1) inside the left main wheel well, and minor damage to structural parts adjacent to that area. Scattered hydraulic fluid leakage in the left main wheel well was found after the Aircraft landed (figure 5).

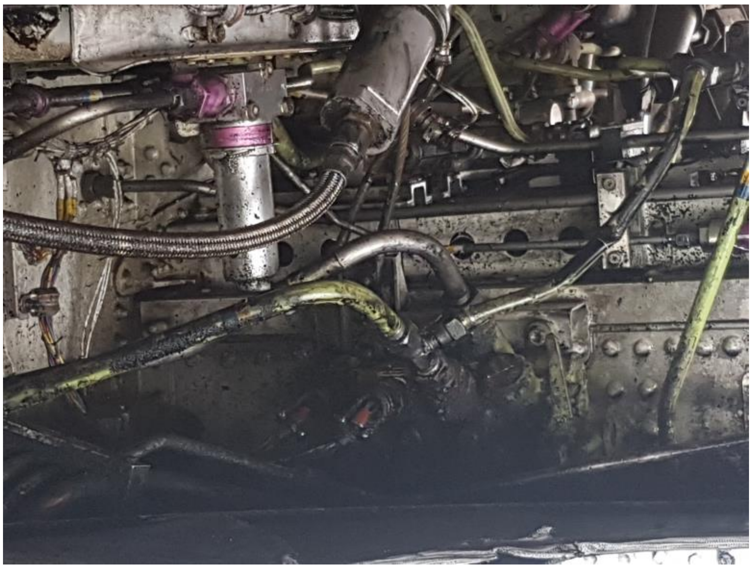

Figure 5. Scattered hydraulic oil leakage in the left main wheel well

1.4 Other Damage

There was no damage to property, or the environment.

1.5 Personnel Information

The information of the Commander and Co-pilot at the time of the Incident, are as shown in table 2.

Table 2. Flight crewmembers data		
	Commander	Co-pilot
Age	44	42
Gender	Male	Male

Type of license	ATPL[4]	ATPL
Valid to	21 December 2023	21 December 2024
Rating	M/E LAND, B737 300-900	M/E LAND, B737 300-900 (P2)
Total flying time (hours)	9511	6902.85
Total Command on all types (hours)	5161	5161
Total on this type (hours – only with flydubai)	2997.1	458.6
Total twelve months (hours)	823.82	489.98
Total on type the last 28 days	73.00	47.73
Total last 7 days (hours)	21.92	14.27
Total on type last 7 days (hours)	21.92	14.27
Total last 24 hours (hours)	1.25	1.25
Last recurrent SEP[5] training	5 July 2017	23 October 2016
Last proficiency check	4 June 2017	7 December 2016
Last line check	15 December 2016	11 January 2017
Medical class	Class 1	Class 1
Valid to	3 September 2017	5 November 2017
Medical limitation	Nil	Nil
English language proficiency (ELP)	Level 4	Level 5

The flight crews qualifications and experience were not factors in the Incident.

The rosters and information of both flight crewmembers provided to the Investigation were reviewed and evaluated, which indicated that fatigue was not a factor in the Incident.

1.6 Aircraft Information

1.6.1 Aircraft data

Table 3 illustrates general information of the Aircraft as of the date of the Incident.

Table 3. Aircraft data

Manufacturer:	The Boeing Company
Model:	B737-8KN
Manufacturer serial number:	40246
Nationality and registration mark:	United Arab E, A6-FDS
Name of the Operator:	flydubai
Certificate of airworthiness	
Number:	FLD/19
Original issue date:	3 June 2011
Re-issue date:	27 May 2013
Valid to:	*Airworthiness Review Certificate ARC-FZ-FDS-5* 1 June 2018
Certificate of registration	

4 ATPL: Air transport pilot license

5 *SEP: Safety and emergency procedures*

Number:	34/11
Original issue date:	3 June 2011
Re-issue date:	23 March 2014
Valid to:	Open
Date of delivery:	3 June 2011
Time since new (flight hours):	26,246.7 Hours
Cycles since new:	11,198
Last inspection and date:	25 June 2016 (C-04 Check)
Time since last overhaul (flight hours):	4,082.65
Cycles since last overhaul:	1,935
Maximum take-off weight:	79,015 kg
Maximum landing weight:	66,360 kg
Maximum zero fuel weight:	62,731 Kg

1.6.2 Engine data

Table 4 illustrates general information of the engines as of the date of the Incident.

Table 4. Engine data

Manufacturer:	CFM	
	No. 1 engine	No. 2 engine
Model:	CFM56-7B	CFM56-7B
Manufacturer serial number:	961407	804987
Date installed on Aircraft:	17 January 2017	25 November 2014
Time since new (hours):	16,220	25,233
Cycles since new:	7,052	10,776
Time since last overhaul (hours):	2,347	11,412
Cycles since last overhaul:	928	4,768

1.6.3 Hydraulic system

1.6.3.1 Type general information

The B737-800 has three hydraulic systems: A, B and Standby. The Standby system is used if system A and/or B pressure is lost. The hydraulic systems power the following aircraft systems:

- flight controls
- leading edge flaps and slats
- trailing edge flaps
- landing gear
- wheel brakes
- nose wheel steering
- thrust reversers
- autopilots.

Either A or B hydraulic system can power all flight controls with no decrease in Aircraft controllability.

Each hydraulic system has a fluid reservoir located in the main wheel well area. System A and B reservoirs are pressurized by bleed air. The Standby system reservoir is connected to the system B reservoir for pressurization and servicing.

Pressurization of all reservoirs ensures positive fluid flow to all hydraulic pumps.

A schematic of the hydraulic power distribution is shown in figure 6.

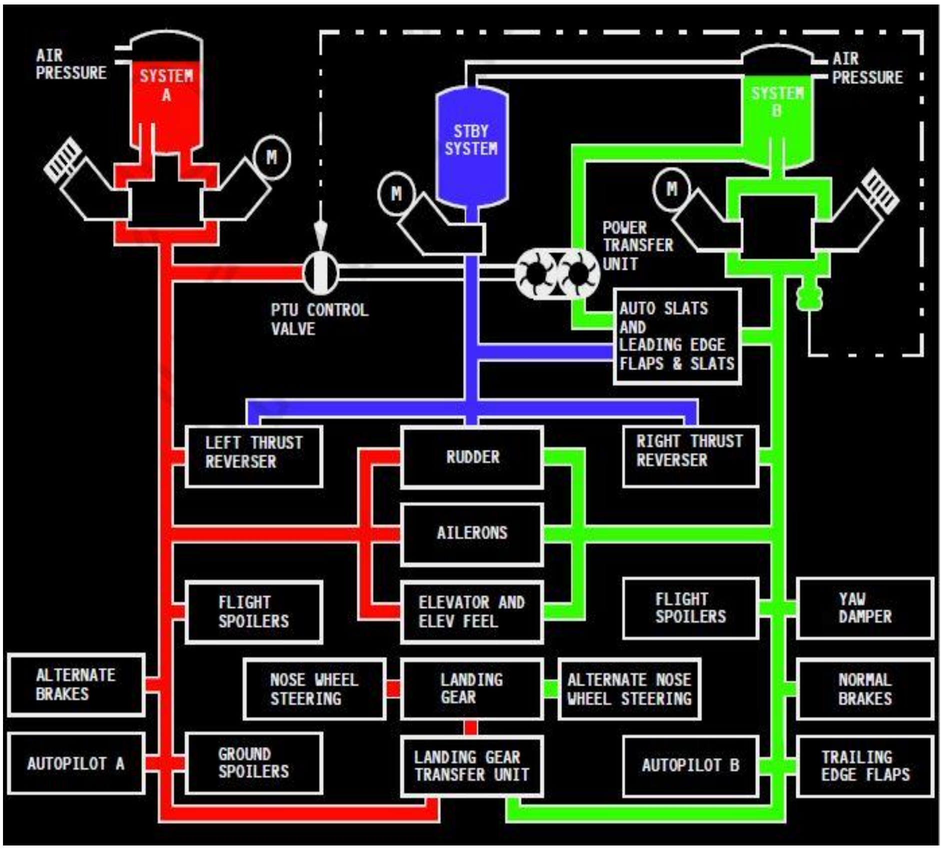

Figure 6. Hydraulic power distribution [Copyright © Boeing. Reprinted with permission of The Boeing Company]

The hydraulic system A powers the following components:

- ailerons
- rudder
- elevator and elevator feel
- flight spoilers (two on each wing)
- ground spoilers
- alternate brakes
- No.1 thrust reverser
- autopilot A
- normal nose wheel steering
- landing gear
- power transfer unit (PTU)

While, the hydraulic system B powers the following components:

- ailerons
- rudder

- elevator and elevator feel
- flight spoilers (two on each wing)
- leading edge flaps and slats
- trailing edge flaps
- normal brakes
- No.2 thrust reverser
- autopilot B
- alternate nose wheel steering
- landing gear transfer unit
- autoslats
- yaw damper

The standby hydraulic system is provided as a backup if system A and/or B pressure is lost. The standby system can be activated manually or automatically and uses a single electric motor–driven pump to power:

- thrust reversers
- rudder
- leading edge flaps and slats (extend only)
- standby yaw damper.

1.6.3.2 Hydraulic system pumps

Both A and B hydraulic systems have an engine-driven pump and an AC electric motor-driven pump. The system A engine-driven pump is powered by the No. 1 engine and the system B engine-driven pump is powered by the No. 2 engine. An engine-driven hydraulic pump supplies approximately six times the fluid volume of the related electric motor-driven hydraulic pump.

The ENG 1 (system A) or ENG 2 (system B) pump ON/OFF switch controls the engine-driven pump output pressure (figure 7). Positioning the switch to OFF isolates fluid flow from the system components. However, the engine-driven pump continues to rotate as long as the engine is operating.

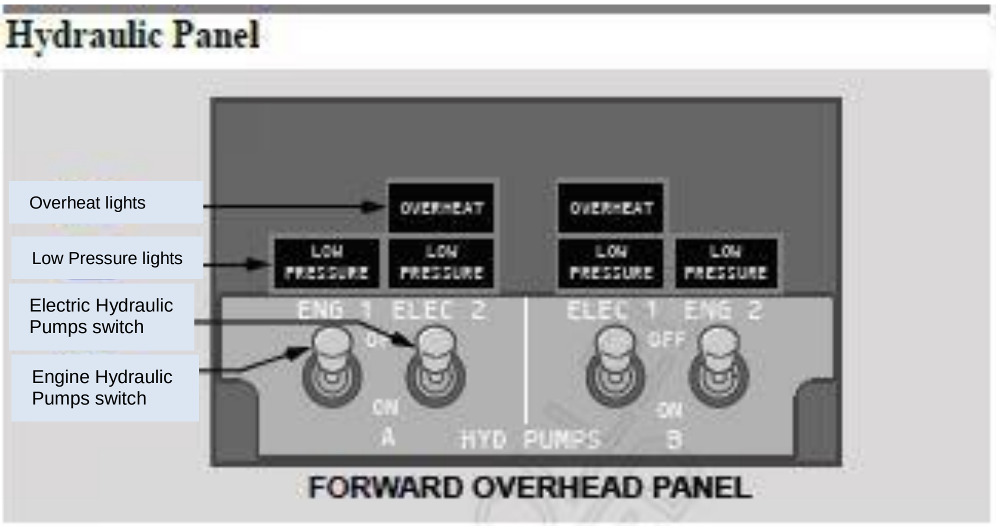

Figure 7. Hydraulic panel [Copyright © Boeing. Reprinted with permission of The Boeing Company]

The ELEC 2 (system A) or ELEC 1 (system B) pump ON/OFF switch controls the related electric motor-driven pump. If an overheat is detected in either system, the related OVERHEAT light illuminates, power is removed from the pump and the LOW PRESSURE light illuminates.

Loss of an engine-driven hydraulic pump and a high demand on the system may result in an intermittent illumination of the LOW PRESSURE light for the remaining electric motor-driven hydraulic pump. The flight control LOW PRESSURE light, Master Caution light, and the FLT CONT and HYD system annunciator lights also illuminate.

1.6.3.3 Leak of hydraulic system A

If a leak develops in the engine-driven pump or its related lines, a standpipe in the reservoir prevents a total system fluid loss. With fluid level at the top of the standpipe, the reservoir quantity displayed indicates approximately 20% full. System A hydraulic pressure is maintained by the electric motor-driven pump.

If a leak develops in the electric motor-driven pump or its related lines, or components common to both the engine and electric motor-driven pumps, the quantity in the reservoir steadily decreases to zero and all system pressure is lost.

1.6.3.4 Manual and automatic operation

Positioning either FLT CONTROL switch to STBY RUD (figure 8):

- activates the standby electric motor–driven pump
- shuts off the related hydraulic system pressure to ailerons, elevators and rudder by closing the flight control shutoff valve
- opens the standby rudder shutoff valve
- deactivates the related flight control LOW PRESSURE light when the standby rudder shutoff valve opens
- allows the standby system to power the rudder and thrust reversers.
- illuminates the STBY RUD ON, Master Caution, and Flight Controls (FLT CONT) lights.

Positioning the ALTERNATE FLAPS master switch to ARM:

- activates the standby electric motor–driven pump
- closes the trailing edge flap bypass valve
- arms the ALTERNATE FLAPS position switch
- allows the standby system to power the leading edge flaps and slats and thrust reversers.

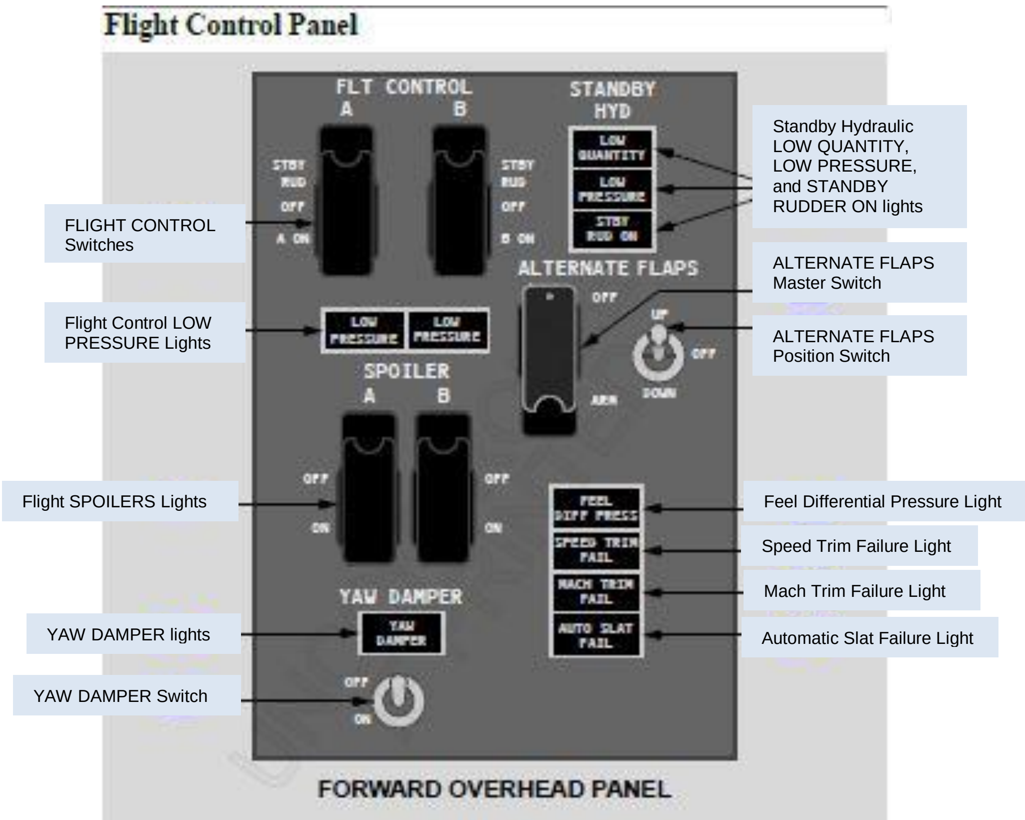

Figure 8. Flight control panel [Copyright © Boeing. Reprinted with permission of The Boeing Company]

Automatic operation is initiated when the following conditions exist:

- loss of system A or B, and
- flaps extended, and
- airborne, or wheel speed greater than 60 knots, and
- FLT CONTROL switch A or B Hydraulic System ON

OR:

- the main PCU Force Fight Monitor (FFM) trips

Automatic operation:

- activates the standby electric motor–driven pump
- opens the standby rudder shutoff valve
- allows the standby system to power the rudder and thrust reversers.
- illuminates the STBY RUD ON, Master Caution, and Flight Controls (FLT CONT) lights.

1.6.4 Landing gear

The landing gear of the B737-800 consists of a conventional two-wheel left and right axle main gear, and steerable two-wheel nose gear.

Hydraulic system A normally supplies power for landing gear retraction, extension, and nose wheel steering. A manual landing gear extension system and an alternate source of hydraulic power for nose wheel steering are also provided.

The normal brake system is powered by hydraulic system B. The alternate brake system is powered by hydraulic system A. Antiskid protection is provided on both brake systems, but the autobrake system is available only with the normal brake system.

The LANDING GEAR lever controls the landing gear (figure 9). On the ground, a landing gear lever lock prevents the LANDING GEAR lever from moving to the up position.

An override trigger in the lever may be used to bypass the landing gear lever lock. In flight, the air/ground system energizes a solenoid, which opens the lever lock.

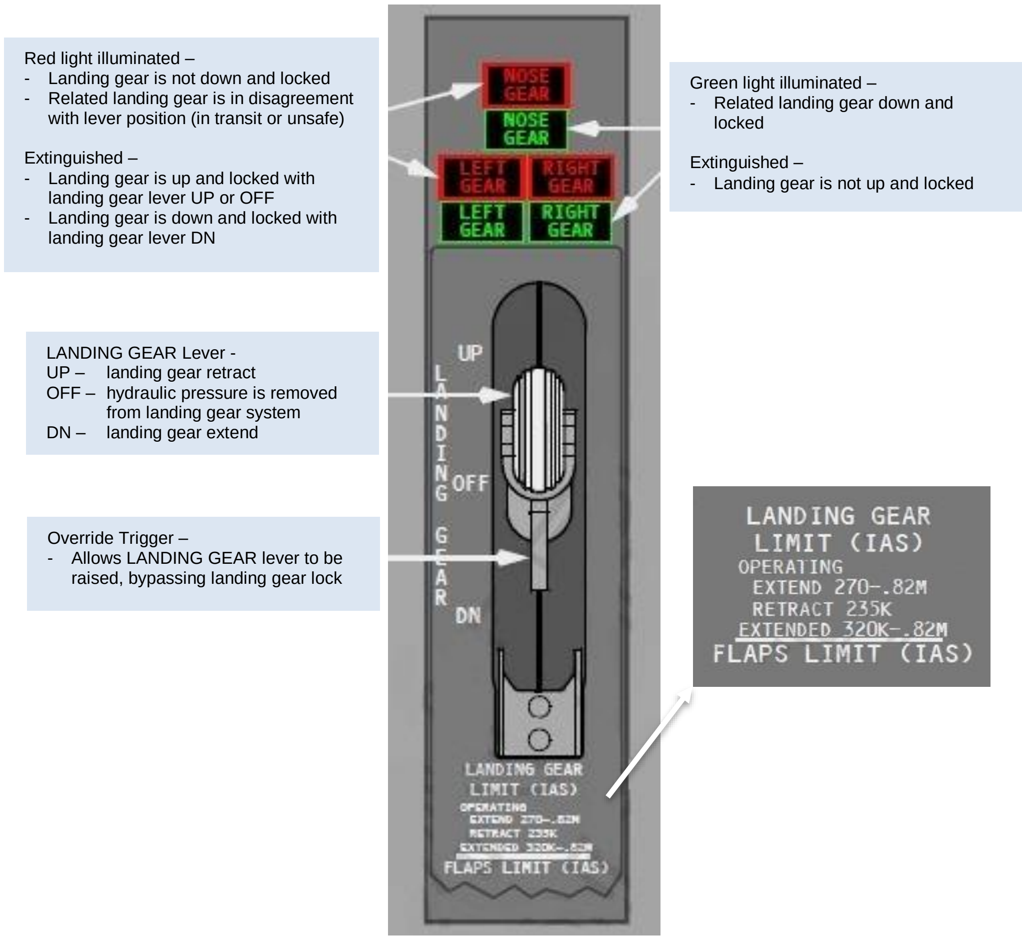

Figure 9. Landing gear panel on forward overhead panel

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1.6.4.1 Landing gear retraction

When the landing gear lever is moved to the UP position, the landing gear starts to retract. During retraction, the brakes automatically stop the rotation of the main gear wheels. After retraction, the main gear is held in place by mechanical up-locks.

Rubber seals and oversized hubcaps complete the fairing of the outboard wheels.

The nose wheels retract forward into the wheel well and nose wheel rotation is stopped by snubbers. The nose gear is held in place by an overcenter lock and enclosed by doors which are mechanically linked to the gear.

Hydraulic pressure is removed from the landing gear system with the landing gear lever in the OFF position.

A spinning tire with a loose tread must be stopped prior to entering the wheel well or it can cause damage to wheel well components. When a spinning tire with loose tread impacts a fitting in the wheel well ring opening, hydraulic system A fluid/pressure being supplied to the associated main gear actuator will be lost and that gear stops retracting and free falls back to the down position. The affected gear cannot be retracted until the fitting is replaced.

1.6.4.2 Landing gear extension and manual extension

When the landing gear lever is moved to DN, hydraulic system A pressure is used to release the up-locks. The landing gear extends by hydraulic pressure, gravity and air loads. Over center mechanical and hydraulic locks hold the gear at full extension. The nose wheel doors remain open when the gear is down.

If hydraulic system A pressure is lost, the manual extension system (figure 10) provides another means of landing gear extension. Manual gear releases on the flight deck are used to release up-locks that allow the gear to free-fall to the down and locked position. The forces that pull the gear down are gravity and air loads.

With the manual extension, access door open:

- manual landing gear extension is possible with the LANDING GEAR lever in any position
- normal landing gear extension is possible if hydraulic system A pressure is available
- landing gear retraction is disabled.

Following a manual extension, the landing gear may be retracted normally by accomplishing the following steps:

- close the manual extension access door
- move the landing gear lever to DN with hydraulic system A pressure available, and then
- position the landing gear lever to UP.

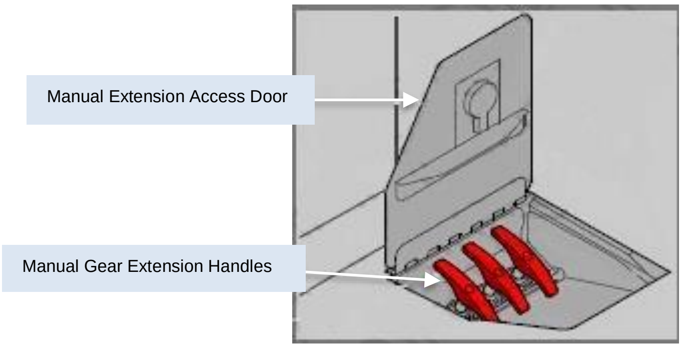

Figure 10. Manual gear extension handles on flight deck floor
[Copyright © Boeing. Reprinted with permission of The Boeing Company]

1.6.5 Hydraulic Brake System

The B737-800 is equipped with a braking system in which each main gear wheel has a multi–disc hydraulic powered brake. The brake pedals provide independent control of the left and right brakes. The nose wheels have no brakes. The brake system includes normal brake system, alternate brake system, brake accumulator, antiskid protection, autobrake system, and parking brake.

The normal brake system is powered by hydraulic system B to operate the brakes.

The antiskid hydraulic system consists of six identical antiskid valves; four for normal braking (one for each wheel) and two alternate antiskid valves (one for each wheel pair).

These are located downstream of the normal and alternate brake metering valves and pressure transducers. Their function is to prevent wheel skid during braking operations.

The alternate brake system is powered by hydraulic system A to operate the brakes. If hydraulic system B is low or fails, hydraulic system A automatically supplies pressure to the alternate brake system.

The brake accumulator is pressurized by hydraulic system B. If both normal and alternate brake system pressure is lost, trapped hydraulic pressure in the brake accumulator supplies pressure to the normal brake system to operate several braking applications or parking brake application.

During landing gear retraction, the alternate brake system gets pressure to operate the brakes, which stops wheel rotation before the landing gear retracts.

Brake hydraulic source selection uses the alternate brake selector valve and the accumulator isolation valve to control different pressure sources supplying pressure for the functions of normal brakes, alternate brakes, and accumulator brakes.

The brake pedals control the normal and the alternate brake systems.

The gear retract pressure operates the alternate brake metering valves to the brakes applied position, which stops wheel spin before the gears go into the wheel well. Movement of the gear retract handle also sends a signal to the autobrake/antiskid control unit to prevent operation of the antiskid system during gear retraction. This will allow the wheels to stop prior to entering the wheel well.

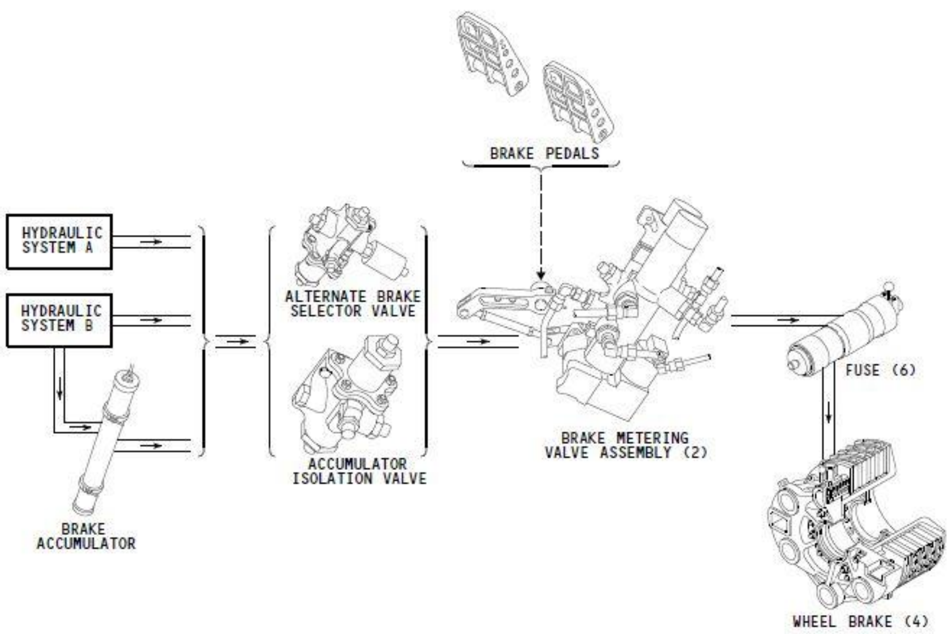

Figure 11. Hydraulic brake system – general description

The brake metering valve assemblies, as shown in figure 11, have these components:

- Normal metering valve
- Alternate metering valve
- Gear retract braking actuator.

The normal brake metering valve uses hydraulic system B or accumulator pressure for the normal brake system.

The alternate brake metering valve uses hydraulic system A pressure for the alternate brake system when hydraulic system B does not supply pressure to normal brake metering valve. The valve also uses pressure from the landing gear retract line to stop the main gear wheel rotation during retraction.

When the normal brake system receives pressure during landing gear retraction, the alternate brake selector valve sends landing gear retract pressure to the alternate brake system. The gear retract pressure operates the alternate brake metering valves to the brakes applied position, which stops wheel spin before the gears go into the wheel well.

When the pressure in one hydraulic brake source decreases, the alternate brake selector valve changes position to set the next available source. This pressure goes to the normal or alternate brake metering valves.

The accumulator isolation valve closes to hold pressure in the brake accumulator during alternate brake operation. The accumulator isolation valve opens to send accumulator pressure to the normal brake metering valves when hydraulic system A and B do not supply pressure.

During main landing gear retraction, the function of the frangible fitting is to remove up pressure from the main landing gear actuator when a damaged, spinning tire moves into the main landing gear wheel well. This prevents damage to components in the wheel well.

The location of the frangible fitting is on the outboard side of both wheel well rings in the main landing gear wheel well (figure 12).

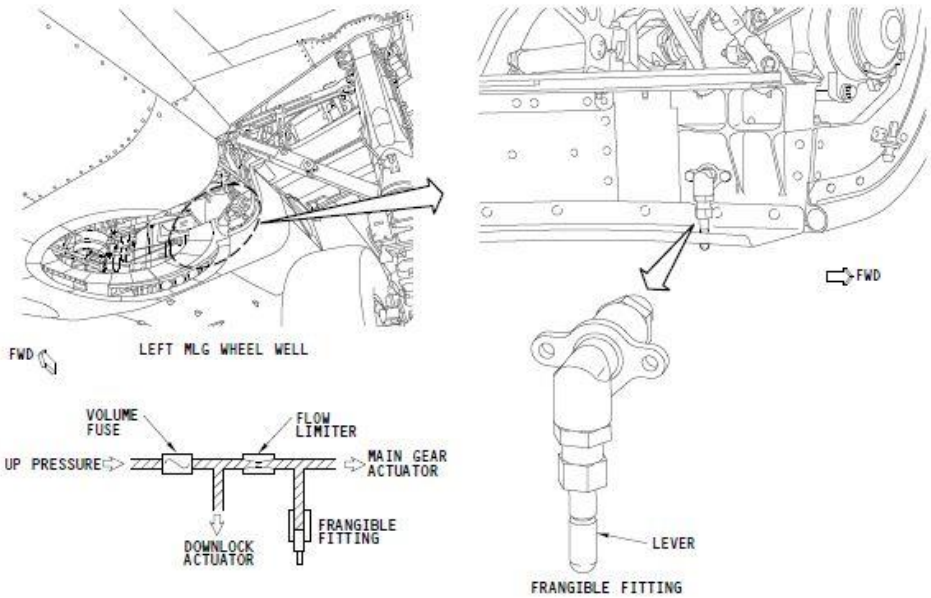

Figure 12. Frangible fitting [Copyright © Boeing. Reprinted with permission of The Boeing Company]

The frangible fitting is a normally closed valve. It opens when a force removes the lever from the fitting.

The fuse prevents hydraulic system fluid loss when the frangible fitting operates.

A flow limiter in the up pressure line limits the flow to the main landing gear actuator to 8 gpm (gallons per minute) or 30 lpm (liters per minute). The flow limiter makes sure hydraulic system pressure stays normal for other airplane systems that also use hydraulic pressure. The flow limiter also controls the transfer cylinder rate and the main landing gear extension and retraction rate.

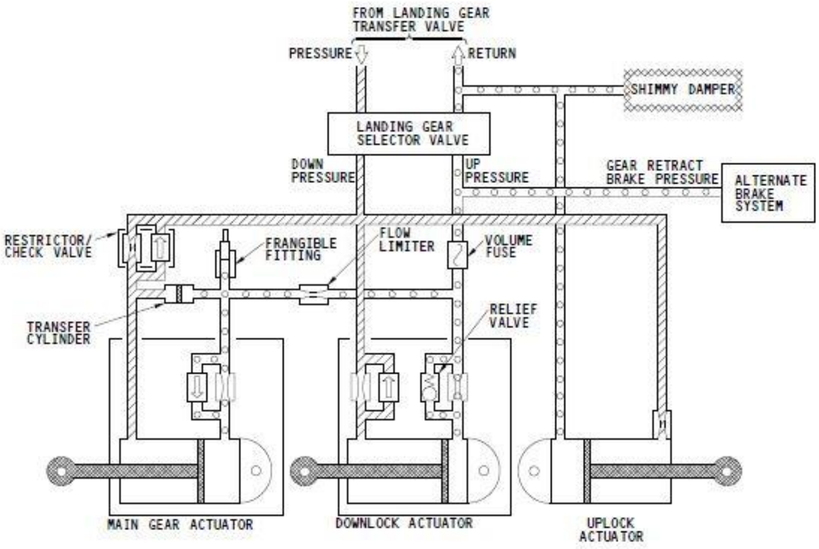

Figure 13. Functional description of main landing gear extension and retraction
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The frangible fitting operates during this sequence of events:

- A section of tread partially separates from a main landing gear tire
- Landing gear starts to retract
- Gear retract braking has a fault and does not stop the wheel rotation before it moves into the wheel well
- The section of tread removes the lever from the frangible fitting
- Frangible fitting opens
- Up pressure is removed from the main landing gear actuator
- Main landing gear that has the damaged tire stops retraction and moves towards the extended position
- Flow limiter in the up pressure line limits the flow to 8 gpm (30 lpm) from the volume fuse to the frangible fitting and MLG actuator
- Volume fuse in the up pressure line closes when the hydraulic flow through the frangible fitting increases to 180-250 cubic inches (3-4 liters). This stops the loss of fluid from the hydraulic system.

When the landing gear lever is set in the up position, the antiskid system stops alternate antiskid operation in order to permit gear retract braking during landing gear retraction. This occurs during the 12.5 seconds after the landing gear lever moves to the UP position, which permits gear retract braking to stop the wheels during landing gear retraction without antiskid brake release.

1.6.6 Speedbrakes, flight spoilers, and ground spoilers

The B737-800 is equipped with speed brakes, which consists of flight spoilers and ground spoilers. Hydraulic system A powers all four ground spoilers: two on the upper surface of each wing.

The speedbrake (SPEED BRAKE) lever controls the spoilers. When the speedbrake lever is actuated, all spoilers extend when the aircraft is on the ground, and only the flight spoilers extend when the aircraft is in the air.

The SPEEDBRAKES EXTENDED light provides an indication of spoiler operation in-flight and on the ground. In-flight, the light illuminates to warn the flight crew that the speed brakes are extended while in the landing configuration or below 800 feet above ground level (AGL).

The Aircraft has eight flight spoilers: four on each wing. Each of the hydraulic systems, A and B, are dedicated to a different set of spoiler pairs to provide isolation and maintain symmetric operation in the event of hydraulic system failure.

Hydraulic pressure shutoff valves are controlled by the two flight SPOILER switches.

Flight spoiler panels are used as speed brakes to increase drag and reduce lift, both in-flight and on the ground. The flight spoilers also supplement roll control in response to control wheel commands. A spoiler mixer, connected to the aileron cable-drive, controls the hydraulic power control units on each spoiler panel to provide spoiler movement proportional to aileron movement.

The flight spoilers rise on the wing with up aileron and remain faired on the wing with down aileron. When the control wheel is displaced more than approximately 10 degrees, spoiler deflection is initiated.

Operating the speed brake lever in-flight causes all flight spoiler panels to rise symmetrically to act as speed brakes. Moving the speed brake lever beyond the FLIGHT DETENT causes buffeting and is prohibited in flight.

A lever stop feature is incorporated into the speed brake lever mechanism. The lever stop prevents the speed brake lever from being moved beyond the FLIGHT DETENT when the aircraft is in flight with the flaps up.

During landing, the auto speed brake system operates when these conditions occur:

- Speed brake lever is in the armed position
- Speed brake armed light is illuminated
- Radio altitude is less than 10 ft
- landing gear strut compresses on touchdown.

  Note: Compression of any landing gear strut enables the flight spoilers to deploy. Compression of the right main landing gear strut enables the ground spoilers to deploy.

- both thrust levers are retarded to IDLE
- main landing gear wheels spin up (more than 60 knots).

The speed brake lever automatically moves to the UP position and the spoilers deploy.

A schematic of flight spoilers, ground spoilers, and speed brake power distribution is shown in figure 14.

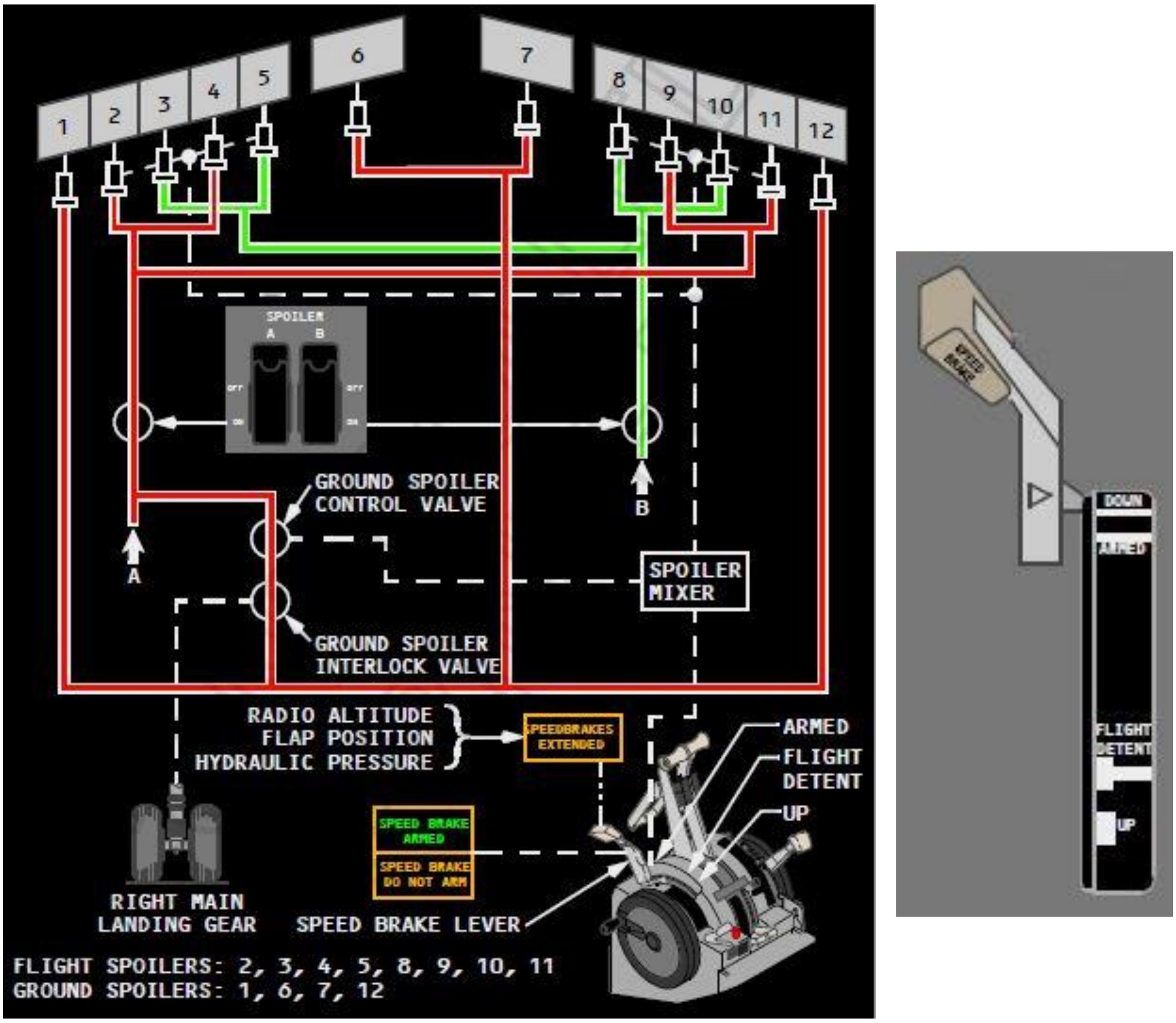

Figure 14. Schematic of flight spoilers, ground spoilers and speed brake
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1.6.7 Thrust reverser

Each engine of the B737-800 is equipped with a hydraulically operated thrust reverser, consisting of left and right translating sleeves. Aft movement of the reverser sleeves causes blocker doors to deflect fan discharge air forward, through fixed cascade vanes, producing reverse thrust. The thrust reverser is for ground operations only and is used after touchdown to slow the aircraft, reducing stopping distance and brake wear.

Hydraulic pressure for the operation of No. 1 engine and No. 2 engine thrust reversers comes from hydraulic systems A and B, respectively. If hydraulic system A and/or B fails, alternate operation for the affected thrust reverser is available through the Standby hydraulic system. When the Standby system is used, the affected thrust reverser deploys and retracts at a slower rate and some thrust asymmetry can be anticipated.

1.6.8 Nose wheel steering

Figure 15. Nose wheel steering

The B737-800 nose wheel steering is available when the nose wheel is in the down position and compressed by the weight of the aircraft. Positioning the landing gear control lever to down makes system A hydraulic pressure available to the steering metering valve. Alternate nose wheel steering can be activated to provide system B pressure to the nose wheels when the nose wheel steering switch is placed to ALT, normal quantity is in the system B reservoir, and the aircraft is on the ground.

1.6.9 Maintenance records

A review of the maintenance records submitted to the Investigation covering the month prior to the Incident indicated that there were no defects or faults related to the Aircraft's hydraulic system.

The following maintenance actions related to the landing gear were accomplished during the month prior to the incident:

- A deep cut was found on the right nose wheel during inspection on 8 July 2017.
- No. 3 main landing gear tire assembly worn to the limit on 15 July 2017.
- No. 1 main landing gear tire assembly worn to the limit on 16 July 2017.
- No. 4 main landing gear tire assembly worn to the limit on 18 July 2017.
- During a walk-around exterior inspection on 25 July 2017, black rubber traces were found in the left main gear wheel well. No damage was found during a detailed inspection. However, it was found that the brake did not automatically stop the rotation of the left main gear wheels during retraction. The left gear retraction brake system was unserviceable, and an acceptable deferred defect (ADD) was raised for further troubleshooting. The Aircraft was released in accordance with *MEL 32-14* Category C and placard applied.
- No. 1 main landing gear tire was found with a worn groove on 25 July 2017.
- A deflated No. 2 main landing gear tire was found on 28 July 2017.

All main landing gear assembly defects were rectified and found satisfactory prior to the next flight operation.

Troubleshooting was performed on the unserviceable left gear retraction braking system on 1 August 2017. Consequently, the wheel well brake-metering valve was replaced, An installation test was carried out in accordance with *AMM 32-41-31-790-001*, and was found satisfactory. Therefore, the ADD was closed.

There was one ADD item open before the flight, and it was “Required cleaning on left main wheel well area.”

During the previous flight from Bishkek-Kyrgyztan to Dubai (flight FDB760), the only defect referred to a cabin item, which was rectified and closed.

1.6.10 Damaged tire

The damaged No. 1 tire, on the left outboard, was a re-tread tire. Table 5 illustrates the information of the tire as of the date of the Incident.

Table 5. Damaged tire information	
Manufacturer:	Michelin
Boeing Part Number:	Boeing Part No. S277AO15-242
Part Number:	029-894-0
Thread Code:	351
Serial Number:	4317R00038
Date	Remark
18 Nov. 2014	First authorized release certificate as a brand new tire (in accordance with FAA Form 8130-2, airworthiness approval tag)
1 Apr. 2015	Received in the Operator's system (AMOS), as a brand new tire (re-tread level R0)
14 June 2015	Tire installed on wheel Assy in the workshop
10 July 2015	Installed on other aircraft on position #1 (left outboard)
15 Aug.2015	Removed from the other aircraft with cycles 176, due to tire worn to limit
1 Sept.2015	Shipped to Michelin
8 June 2016	Tire re-treaded to R1 by Michelin (tread code:351, certificate/approval reference no. FR.145.062)
26 July 2016	Received in the system
22 Aug. 2016	Tire installed on wheel Assy in the workshop
23 Aug 2016	Tire installed on the same other aircraft on position #1
5 Oct. 2016	Tire removed from the aircraft with cycles 204, due to tire worn to limit multiple patches
11 Oct. 2016	Shipped to Michelin
24 Feb. 2017	Tire re-treaded to R2 by Michelin (tread code:351, certificate/approval reference no. FR.145.062)
14 June 2017	Received in system
26 July 2017	Tire installed on the Aircraft on position #1
8 Aug. 2017	Removed from the Aircraft with 66 cycles, after the Incident

1.7 Meteorological Information

Table 6 shows the METAR for Dubai International Airport on 8 August 2017, over the period from 0600 to 0800 UTC.

Table 6. METAR, 8 August 2017, 0600 to 0800 UTC
METAR OMDB 080600Z 16010KT CAVOK[6] 41/13 Q1001 NOSIG=[7] METAR OMDB 080700Z 15007KT CAVOK 42/15 Q1001 NOSIG METAR OMDB 080800Z 15005KT CAVOK 44/13 Q1000 BECMG 32012KT

Table 7 describes the above mentioned METAR.

[6] CAVOK stands for ceiling and visibility okay, which means that the visibility is 10 kilometers or more and no clouds below 5,000 ft or below the highest Minimum Safe/Sector Altitude (MSA) whichever is the highest

[7] NOSIG means that no significant change is expected to the reported conditions within the next two hours

Table 7. Description of the METAR			
	0600 UTC	0700 UTC	0800 UTC
Wind	Direction 160° / speed 10kts	Direction 150° / speed 7kts	Direction 150° / speed 5kts
Visibility	10 km or more	10 km or more	10 km or more
Clouds	No / No significant cloud	No / No Significant cloud	No / No significant cloud
OAT	41°C	42°C	44°C
Dew point	13°C	15°C	13°C
Pressure (Altimeter)	1001 mbar	1001 mbar	1000 mbar
Condition	No significant change	No significant change	Becoming wind direction 320º / speed 12kts

The prevailing meteorological conditions were not a factor in this Incident.

1.8 Aids to Navigation

There were no defects found on the ground-based navigation aids, on-board navigation aids, and visual ground aids, and their serviceability in this Incident.

1.9 Communications

All communications between the flight crew and Dubai Tower on 118.750 MHz, Departure on 121.025 MHz, Approach on 127.900 MHz, and Ground on 121.650 MHz, were clear and normal according to operational standards.

1.10 Aerodrome Information

Dubai International Airport, ICAO code OMDB, coordinates 251510N 0552152E on centreline runway 12R/30L adjacent threshold runway 12R, and is located 2.5 nautical miles east of Dubai, the UAE. The airport elevation is 62 ft.

The airport has two asphalt runways: 12R/30L with a length of 4,450 meters, and 12L/30R with 4,000 meters length.

Runway 12R/30L and 12L/30R are equipped with an ICAO CAT IIIB precision approach lighting system including distance coded centreline with sequence flashing lights from 900 meters to 300, flashing RTIL. The runway centreline lighting is white bi - directional with 15 meters spacing, white coded first 3420 meters, white/red alternate for the next 600 meters, and red for the last 300 meters.

Prior to and after the incident, no foreign object debris was found on runway 12R/30L.

1.11 Flight Recorders

The Aircraft was equipped with a digital flight data recorder (DFDR) and cockpit voice recorder (CVR) as mentioned in table 8.

Table 8. Flight recorders		
	Type	Part Number
CVR	**L-3 Comm**	2100-1020-00
DFDR	**Honeywell**	980-4700-042

Data from the DFDR and CVR were downloaded and analyzed, and the Investigation retrieved useful information from both recorders.

Detailed relevant read-out and event descriptions from the DFDR and CVR data were examined, as given in appendix 2. Prior to that, the time between the DFDR and CVR data was synchronized.

1.12 Wreckage and Impact Information

The Aircraft was intact.

1.13 Medical and Pathological Information

No medical or pathological investigations were conducted as a result of the Incident, nor were they required.

1.14 Fire

There was no sign of fire.

1.15 Survival Aspects

None of the persons on-board sustained any injury.

1.16 Tests and Research

1.16.1 Examination of the damaged tire

The damaged tire was shipped to the tire manufacturer (Michelin) for an examination of the cause of the damage. The manufacturing and re-tread records of the tire were reviewed by the manufacturer, and found to be in accordance with the manufacturer's specifications.

The tire manufacturer's report noted that the tire had lost the complete center tread rib, exposing the top belt ply (figure 16a). In one area, the top belt ply was abraded, lost, or torn away (figure 16b). The shoulder and intermediate tread rib opposite the serial side exhibited cuts and scratches (figure 16c).

In the center inner tread groove opposite serial side sector 5, a trace of cut/damage with tear-lines visible on the top belt ply extending out of this cut/damage (figure 16d), is evident.

The tire manufacturer's report concluded that the tear-lines visible on the top belt ply, and the trace of cut/damage on the center inner tread groove opposite serial side in sector 5, indicate a possible initiation site for the loss of the center tread rib. As the missing tread pieces were not returned, the tire manufacturer could not determine the root cause for the center tread rib loss.

(a)

(b)

(c)

(d)

Figure 16. Damaged tire [Source: Michelin]

1.16.2 Testing of brake system on landing retraction

After the Incident, the Operator performed operational test of the gear retract braking. The objective was to establish if the gear retract braking system was functioning when the landing gear was retracted on the Incident flight.

The testing was conducted after all required inspections, replacement of damaged components, and the related operational test were carried out, as in accordance with the AMM. The Operator reported that the operational test revealed that the left main landing gear retract brake system functioned normally, as confirmed by assessing the brake wear pin indicator in accordance with AMM 32-41-00, which means that the hydraulic pressure had been applied. Following this testing, however, the operator removed several left main landing gear components, which were sent to their respective vendors for testing and overhaul. One of those components was the left alternate antiskid valve. The operator reported that that this valve was tested in the shop and found to be faulty.

1.17 Organizational and Management Information

1.17.1 General information

The Operator was established in July 2008, and granted air operator certificate (AOC) issued by the General Civil Aviation Authority of the United Arab Emirates for transport passengers.

1.17.2 Training

All required training for the Operator's pilots was described in the Part D1 of the *Operations Manual – Flight Crew Training*.

Hydraulic system failure was included in the Operator's B737-800 First Type Rating Course, Conversion Course, and Recurrent Training.

The subject was covered at least twice every three years in the recurrent training program, in accordance with the Part D1of the *Operations Manual*.

Based on the training records, both flight crewmember had attended the required training, which included hydraulic system failure (single and dual failure) as per the Part D1 of the *Operations Manual*.

The Operator provided a *flight crew training manual (FCTM)* as a supplement to the *flight crew operating manual (FCOM)*, which was designed to provide information and recommendations on maneuvers and techniques on B737-800, developed and recommended by the manufacturer, and accepted by the Federal Aviation Administration (FAA) of the United States for use in flight operations. These maneuvers and techniques were provided as guidance and do not prevent the operator from developing equivalent maneuvers or techniques in accordance with the applicable operating rules.

1.17.3 Procedures

1.17.3.1 *After takeoff checklist*

The *after take-off* normal checklist was described in the manufacturer's *quick reference handbook (QRH)*, as following:

“ AFTER TAKEOFF

Engine bleeds………..……………………………..…ON

Packs…...…………………………..…...………….AUTO

Landing Gear……..…...……………………UP and OFF

Flaps…………………………………….…..UP, No lights”

1.18.2.2 Checklists for loss of hydraulic system A

The checklists related to a loss of hydraulic system A were described in the *QRH*, as following:

“

FLT CONTROL		A HYD PUMPS	
A		ENG 1	ELEC 2
LOW PRESSURE		LOW PRESSURE	LOW PRESSURE

Condition: Hydraulic System A pressure is low

1 System A

FLT CONTROL switches……Confirm……..….STBY RUD

2 System A

HYD PUMP switches (both)……..……...…………..…OFF

3 Check the Non-Normal Configuration Landing Distance table in the Advisory Information section of the Performance Inflight chapter.

4 NOSE WHEEL STEERING switch……..............……ALT

5 Plan for manual gear extension.

Note: When the gear has been lowered manually, it cannot be retracted. The drag penalty with gear extended may make it impossible to reach an alternate field.

Note: Inoperative Items
Autopilot A inop Autopilot B is available.
Flight spoilers (two on each wing) inop Roll rate and speedbrake effectiveness may be reduced in flight.
Normal landing gear extension and retraction Inop Manual gear extension is needed.
Ground spoilers inop Landing distance will be increased.
Alternate brakes inop Normal brakes are available.
Engine 1 thrust reverser normal hydraulic pressure inop Thrust reverser will deploy and retract at a slower rate and some thrust asymmetry can be anticipated during thrust reverser deployment.
Normal nose wheel steering inop Alternate nose wheel steering is available.

6 **Checklist Complete Except Deferred Items**

Deferred Items

Descent Checklist

Pressurization ……………………………LAND ALT ___

Recall……………………………………………Checked

Autobrake…………………………………….……____

Landing data…………………Vref____, Minimums____

Approach briefing…………………………….…Completed

Approach Checklist

Altimeters…………………………………………..…____

Manual Gear Extension

LANDING GEAR lever………..……………....…..…OFF

Manual gear extension handles…........……….….Pull

The uplock is released when the handle is pulled to its limit.

The related red landing gear indicator light illuminates, indicating uplock release.

Wait 15 seconds after the last manual gear extension handle is pulled:

LANDING GEAR lever…………….………………..DN

Landing Checklist

ENGINE START switches……………………....CONT

Speedbrake……………………..………...…ARMED

Landing gear……………………………………...Down

Flaps…………………………………____, Green light

"

1.18 Additional Information

The type certification basis of the B737-800 aircraft was based on *14CFR Part 25 of the Federal Aviation Regulations* up to amendment 25-77 was, and the aircraft type was certified on 13 March 1998 as a transport aircraft.

The landing gear installed on the Aircraft complied with the *Federal Aviation Regulations* (FAR), Section 25.1309 (b) which contained certification specifications for any failure condition of equipment, systems, and installations, which would protect continued safe flight and landing of the airplane. The specifications state, as following:

"§25.1309 Equipment, systems, and installations.

…

(b) The airplane systems and associated components, considered separately and in relation to other systems, must be designed so that -

(1) The occurrence of any failure condition which would prevent the continued safe flight and landing of the airplane is extremely improbable, and

(2) The occurrence of any other failure conditions which would reduce the capability of the airplane or the ability of the crew to cope with adverse operating conditions is improbable."

1.19 Useful or Effective Investigation Techniques

This Investigation was conducted in accordance with Part VI, Chapter 3 of the United Arab Emirates *Civil Aviation Regulations*, and the AAIS approved policies and procedures, and in conformity with the Standards and Recommended practices of *Annex 13 to the Chicago Convention*.

2. Analysis

The Investigation collected data from various sources for the purpose of determining the causes and contributing factors that led to the Incident.

This Analysis covers the tire damage and the consequences, the effect on Aircraft systems due to the loss of hydraulic system A and the related Operator's procedures.

This part of the Report explains the contribution of every investigation aspect to the Incident.

The Analysis also contains safety concerns that may not be contributory to the Incident but are significant in adversely affecting safety.

2.1 The Damaged Tire

Although the No. 1 landing gear tire was damaged during takeoff, it was still inflated until the Aircraft returned to the parking stand after the flight.

The tread pieces were not found after the Incident. It is most probable that the debris was lost from the wheel well, when the left main gear was extending, after it had not reached the up and locked position.

For further examination, the damaged tire was sent to the tire manufacturer, who concluded that the tear-lines visible on the top belt ply, and the trace of cut/damage on the center inner tread groove opposite the serial side in sector 5 exhibited marks of a possible initiation site for the loss of the center tread rib. As the missing tread pieces were not returned, the tire manufacturer stated that they could not determine the root cause of the center tread rib loss. It is important to locate all tread parts or debris of the damaged tire in the case of tread separation, because these are the parts, which were in contact with the ground when the damage occurred.

The trace of a cut with tear-lines on the top belt ply that extended out of the cut was possibly caused by a foreign object debris (FOD) or rough ground surface. However, the Investigation could not determine where, when and how the cut damage had occurred. There was no evidence that any FOD was present on the runway during the take-off, nor on other aircraft takeoff and landing, prior to or after the take-off of the Incident Aircraft. However, it is possible that the cut occurred on a previous flight and, was not detected on the inspections prior to the Incident.

Premature signs of tire internal components separations, such as bulges, localized rubber splits, or uneven wear, may be a sign of delamination damage. In that case, it is important to remove tires from service when any evidence of separation is observed before a flight. During ground roll and high-speed rotation, even small areas of tread separation may grow into partial or full tread rubber loss. However, there was no evidence that the No. 1 tire had internal components separations prior to the flight.

The tire had been re-treaded twice prior to the Incident. It had been installed on the Aircraft 13 days after the second re-treading that was carried out by the tire manufacturer according to the manufacturer's specifications. The tire had been in service for 66 cycles prior to the Incident.

Although the Investigation could not determine the cause of the tire damage, the Investigation believes that the Operator should include re-treaded tires in its reliability program, and to ensure that on-wing monitoring of nose and main wheel tire pressures is sufficiently robust to ensure TSO specifications for re-tread tire integrity are maintained throughout the tire operational spectrum. The reliability program should also consider the operational and environmental conditions.

A non-destructive test (NDT) inspection (shearography) is required for tire re-treading to identify any abnormalities.

According to the Boeing *Service Letter 737-SL-32-128-A* – *Tire Retreading Recommendations*, the re-treaded tires are recommended to go for NDT checks for an extent dependent on the re-tread level. Boeing recommended that the NDT inspection covers: the crown area for retread levels 0, 1 and 2; and the whole tire (bead-to-bead) for level 3 and beyond.

Following the Incident, the Operator has taken a safety action by ensuring that the contracted re-treading agencies perform the required NDT checks dependent upon the retread levels as suggested by the Aircraft manufacturer and issued through Boeing *Service Letter 737-SL-32-128-A*, in addition to inspection requirements raised by the reliability data.

The Investigation also reviewed the flight data prior to and during the takeoff. There was no evidence that the operations resulted in a significant lateral acceleration, which could have caused a substantial incremental side load on the tires, and could have contributed to the tire damage.

Recent ramp inspections of other Operator's aircraft conducted by the GCAA prior to the Incident, indicated that there were no issues related to tires observed during the inspections.

The pressure of all tires was also checked after the Incident, and it indicated that two tires were within limits, and four tires were above the maximum limit.

In order to improve detection of tire pressures, the Investigation recommends that the GCAA ensure that air operators on-wing monitoring of nose and main wheel tire pressures is sufficiently robust to ensure TSO specifications for re-tread tire integrity are maintained throughout the tire operational spectrum.

2.2 The Loss of Hydraulic System A and the Effect on Aircraft Systems

The hydraulic system of the Aircraft was designed with built-in redundancy. When the Aircraft lost hydraulic system A, system B and the Standby system automatically and manually provided the required hydraulic power to essential systems.

The affected systems on the Aircraft when the hydraulic system A lost, were: autopilot A; flight spoilers (two on each wing); normal landing gear extension and retraction; ground spoilers; alternate brakes; No. 1 engine thrust reverser normal hydraulic pressure; and normal nose wheel steering.

During the takeoff and until the Aircraft lost hydraulic system A, the autopilot was disengaged. The Commander selected autopilot A, which was engaged for approximately 5 seconds, when the Aircraft was climbing through 1,750 feet radio altitude. The Investigation believes that the five seconds engagement of autopilot A was due to the residual hydraulic pressure. The Commander realized that autopilot A was inoperative, and therefore requested the Co-pilot to select autopilot B.

Some of the damaged components were related to the electric motor-driven pump, and to the engine driven pump of hydraulic system A, which caused the complete loss of the hydraulic fluid in the system and a total loss of system pressure.

The Aircraft had eight flight spoilers, four on each wing. Four of the eight flight spoilers were inoperative as the result of the loss of hydraulic system A. Consequently, the effectiveness of Aircraft's roll rate reduced, since the flight spoilers also supplemented roll control in response to control wheel inputs. The Investigation compared the roll rate of the Aircraft between the Incident flight and the previous flight and found that the maximum roll rate of the Aircraft, with autopilot engaged, decreased by about 50% due to the loss of hydraulic system A. The failure of the four of the eight spoilers might also have reduced the effectiveness of the speedbrake.

The speedbrake was armed for the landing, and since hydraulic system B was available, the four system B flight spoilers deployed. The speedbrake lever automatically moved to the UP position.

During the landing, when the Aircraft touched down, the Aircraft's auto brake system functioned normally since the normal brake system, powered by the hydraulic system B, was operative. The Aircraft lost the alternate brake system due to loss of hydraulic system A.

The loss of hydraulic system A during landing gear retraction caused the left main gear and the nose gear to remain in transition and they did not reach the up and locked position. The right main gear reached the up and locked position. Since the landing gear lever was at the up position, the landing gear warning of the left and nose gear appeared. The left and nose gear thereafter fell to the down and locked position.

The nose gear most probably did not reach the up and locked position because the loss of hydraulic system A occurred before the nose gear reached its up and locked position.

The flight crewmembers performed the manual landing gear extension since the normal extension procedure could not be applied due to the hydraulic system A loss and the failure to release the up-locks. The manual gear extension handles were activated by the Co-pilot, which released the up-locks and allowed the right main landing gear to fall into its locked position.

During the landing, the four ground spoilers were inoperative since they were powered by hydraulic system A, as recorded on the flight data. It was also recorded that the spoilers 3 and 10 were deployed on the touchdown, which also means that flight spoilers 5 and 8 (not recorded) were also deployed. Other flight spoilers that were powered by hydraulic system A (2, 4, 9 and 10) were inoperative. This condition resulted in a longer landing distance.

The No. 1 engine thrust reverser was inoperative due to the loss of hydraulic system A. Although the Standby hydraulic system was available to power the No.1 engine thrust reverser, the Commander chose not to apply the thrust reversers for the landing since he was aware that by using the Standby system, the slow rate of the deployment and retraction of the affected thrust reverser could result in thrust asymmetry during landing.

The Investigation compared the landing distance between the Incident flight and one of the previous flights, with the same Aircraft landing configuration (with flaps 30) and similar flight condition (in groundspeed, and almost the same wind direction and speed). The landing distance was measured from when the Aircraft touched the ground, all spoilers deployed in the up position for the other flight of the Aircraft and only operative spoilers deployed for the Incident flight, until the point that the deployed operative spoilers retracted. Auto brakes were applied on both flights. Adjustment of the distance was made since there was a difference in the weight of approximately 5.4 ton, as required by the *airplane flight manual* (*AFM)*. This revealed that the landing distance of the Incident flight was increased by approximately 48 percent due to the loss of hydraulic system A and the decision not to use the thrust reversers on both engines.

Normal nose wheel steering was inoperative due to the loss of hydraulic system A. Consequently, the Commander opened the guarded switch and selected the nose wheel steering switch to ALT, which provided nose wheel steering powered by hydraulic system B. After the landing, no issues were found on the application of the nose wheel steering during taxiing the Aircraft to the parking stand.

All the evidence and the analysis shows that the redundancy of the Aircraft's hydraulic system and the affected systems after the loss of hydraulic system A were operating as designed.

2.3 Flight Operations

Both flight crewmembers operated the flight in accordance with the Operator's *standard operating procedures (SOP)*. They carried out all necessary checklists, including the non-normal checklist for loss of hydraulic system A.

After the loss of hydraulic system A, the Commander requested to enter the hold. His intention was to have sufficient time for both flight crewmembers to understand the problem, make decisions, conduct the necessary failure briefing, and take appropriate action. The Commander also briefed the cabin crew on the situation and the decision to return to OMDB.

The GINLA waypoint provided by the ATC was not a dedicated holding pattern. The Investigation believes that the provided holding area to the Aircraft including the vectoring did not create significant workload issue(s) for the ATCs to manage departures and arrivals at OMDB, since there was no evidence of any ATC issues at the period of the Incident flight.

After the loss of hydraulic system A, the flight crewmembers had no indication that the Aircraft had experienced tire damage. Therefore, the flight crewmembers did not inform ATC about the possibility of debris on the runway.

The external and internal cockpit communications were conducted in accordance with the Operator's procedures.

The Commander was the pilot flying, however, more than once, he transferred the control of the Aircraft to the Co-pilot, when he performed communications with the ATC, the Operator's network control center (NCC), and the cabin crew. The Commander performed these as considered necessary. Nevertheless, high alertness and situational awareness were maintained by both flight crewmembers throughout the flight.

2.4 Brake and Protection on Landing Gear Retraction

The operational test of the gear retract braking performed by the Operator after the Incident, it revealed that the left main landing gear brake system functioned normally, which means that the hydraulic pressure had been applied.

The landing gear retraction of the incident flight started about six second after the Aircraft lifted off.

A portion of the center tread rib of no.1 tire probably peeled off during the takeoff roll and before the landing gear retraction.

After the landing gear lever was set to the up position, the brake pressure increased from 30 to 490 psi, indicating that brake pressure from the metering valve was normal for landing gear retraction. Approximately seven seconds later, a low-pressure indication of hydraulic system A appeared, and the brake pressure decreased to the original pressure value, 30 psi, and after several seconds reduced to zero.

During the seven second transition of the landing gear retraction, the alternate brake selector valve sent landing gear retract pressure (up pressure) to the alternate brake system, which operated the alternate brake metering valves and sent pressure to the brakes. When hydraulic system A was lost, the right main landing gear had fully retracted into the wheel well and both wheels had stopped rotating.

The portion of the peeled center rib of No.1 tire tread did not remove the lever from the frangible fitting since it was found attached to the frangible fitting after the Incident. Therefore, the frangible fitting did not open/operate, and the retraction of the left main landing gear continued. When the left wheel went into the wheel well, the rotating peeled portion of the center tread struck and damaged the components and lines related to hydraulic system A, and other components in the left wheel well. Consequently, the Aircraft lost its hydraulic system A. The loss of hydraulic system A caused the left main landing gear actuator to stop extending, which resulted in the left main landing gear not reaching its up and locked position.

Almost at the same time, the right main landing gear reached its up and locked position. The nose gear retraction stopped and did not reach its up and locked position when hydraulic system A was lost.

Since the frangible fitting did not open or operate, no hydraulic flow went out through the frangible fitting, consequently, the volume fuse did not close the gear up pressure line and the flow limiter never detected the flow limit, since it never reached the limit. This condition resulted in an inability to stop the loss of hydraulic system A fluid. The other outcome was that the gear retraction transition continued, and the gear entered the wheel well. Subsequently, the retraction stopped when the hydraulic system A pressure was lost.

Had the portion of the peeled center rib of the No.1 tire tread removed the lever of the frangible fitting, the loss of hydraulic system A might have been prevented and the hydraulic pressure might have been available for other Aircraft systems that were powered by hydraulic system A. Furthermore, the retraction of the left landing gear may have stopped before the gear entered the wheel well.

The duration of a main gear wheel to stop spinning after the liftoff depends upon some variables, such as: the aircraft speed when lifting off; the time interval between the aircraft lift off and gear retraction; the aerodynamic forces on the tire; the friction of the wheel bearing; the availability of hydraulic pressure from the landing gear retract pressure to the alternate brake metering valves; and the metered hydraulic pressure from the alternate brake metering valve to the brakes.

Based on the flight data available from previous flights of the Aircraft the retraction time was approximately seven seconds, from the gear up lever setting to the up and locked position of the main landing gear, which was also the case for the right main landing gear in this Incident.

For a normally operating brake control system, the manufacturer designed the gear retract braking function to have completely stopped the main gear wheel/tire assemblies from spinning within approximately 1 second after the landing gear lever is moved to the UP position. This includes the time for the landing gear selector valve to provide pressure to the alternate brake metering valve, brake assemblies, and alternate antiskid valve, and the time for the wheel/tire assembly rotation to be stopped. This ensures that the main gear wheel/tire assemblies are not spinning when they begin to enter the wheel wells. The antiskid function is inhibited for 12.5 seconds after the landing gear lever is moved to UP to prevent an antiskid release of the gear retract brake pressure anytime during the gear retraction phase. However, in this event, the Investigation believes that the alternate antiskid valve may have been operating intermittently or in a degraded mode, resulting in an inconsistent and/or incomplete gear retract braking function for the left main gear wheel/tire assembly.

The frangible fitting is essential in preventing damage to the components in the wheel well, as designed in accordance with the certification specification of *FAR 25.1309(b)*. The Investigation could not determine why the frangible fitting did not open or operate, since the lever was still attached following the Incident. Therefore, it is recommended that a risk assessment exercise be carried out by the Aircraft manufacturer on the protection mechanism system of components in the wheel wells considering the functionality of the frangible fitting in a situation of tire damage during landing gear retraction.

On 25 July 2017, two weeks before the Incident, the left gear retraction brake system was found unserviceable. The braking did not stop the rotation of the left main gear wheels during retraction. However, the Aircraft was released for service in accordance with the applicable *minimum equipment list (MEL)* and an acceptable deferred defect (ADD) was raised. On the same day, another acceptable deferred defect was raised regarding the required cleaning on the left main wheel well area due to dirty black rubber traces in the left main gear wheel well.

One week later, on 1 August 2017, the related acceptable deferred defect of the unserviceable retraction brake was closed, after the wheel well brake-metering valve was replaced. However, the acceptable deferred defect of the required cleaning on the left main wheel well area was still open until the Incident.

When an ADD of an unserviceable brake system exists, the Operator should ensure the suitability or fitness of the tire by performing additional checks on the tire.

A clean mainwheel well could provide an indication of the function of the gear retraction brake system, in the case of damaged tire(s), as occurred before the Incident on 25 July 2017. Therefore, the Investigation recommends establishment of appropriate mechanisms to ensure that technical washing of the nose and main wheel well compartments is undertaken with sufficient frequency to allow the integrity of aircraft systems to be assessed sufficiently and continuously. In this regards, a policy is to be established not to defer any maintenance corrective actions without proper documented reference.

3. Conclusions

3.1 General

From the evidence available, the following findings, causes, and contributing factors were made with respect to this Incident. These shall not be read as apportioning blame or liability to any particular organization or individual.

To serve the objective of this Investigation, the following sections are included in the Conclusions heading:

- **Findings-** are statements of all significant conditions, events or circumstances in this Incident. The findings are significant steps in this Incident sequence but they are not always causal or indicate deficiencies.
- **Causes-** are actions, omissions, events, conditions, or a combination thereof, which led to this Incident.
- **Contributing factors-** are actions, omissions, events, conditions, or a combination thereof, which, if eliminated, avoided or absent, would have reduced the probability of the Incident occurring, or mitigated the severity of the consequences of the Incident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil or criminal liability.

3.2 Findings

3.2.1 Findings relevant to the Aircraft

(a) The Aircraft was certificated, equipped, and maintained in accordance with the requirements of the *Civil Aviation Regulations* of the United Arab Emirates.

(b) The Aircraft was airworthy when dispatched for the flight.

(c) The Operator reported that several components were removed and tested following the event. The left antiskid valve was found faulty and may have been operating intermittently.

(d) The Aircraft had one acceptable deferred defect (ADD) related to cleaning the left main wheel well area before the flight. The ADD was still open on the Incident flight.

(e) The No. 1 tire experienced a partial center rib peel during take-off.

(f) During the landing gear retraction, the portion of the peeled center rib of No.1 tire tread did not remove the frangible fitting, which resulted in a continuation of the left main gear retraction.

(g) When the No.1 left wheel went into the wheel well, the rotating peeled portion of the center tread damaged components and lines related to hydraulic system A, consequently, the Aircraft lost its hydraulic system A.

(h) The nose and left main landing gear stopped retracting before reaching the up and locked position, while the right main landing gear reached its up and locked position.

(i) It is most probable that the left alternate antiskid valve was intermittently operating correctly and allowed the spinning wheels of the left main landing gear to enter the wheel well.

(j) The Aircraft returned to the departure airport and landed uneventfully.

(k) There was no evidence of foreign object debris before takeoff.

(l) The tread pieces or debris were not found following the Incident.

(m) The damaged No. 1 tire remained inflated.

(n) The tire manufacturer could not determine the root cause for the center tread rib loss.

3.2.2 Findings relevant to the flight crewmembers

(a) The flight crewmembers were licensed and qualified for the flight in accordance with the existing requirements of the *Civil Aviation Regulations* of the United Arab Emirates.

(b) Both flight crewmembers operated the flight in accordance with the Operator's *standard operating procedures (SOP)*. They carried out all necessary checklists, including the non-normal checklist, for the loss of hydraulic system A.

(c) Both flight crewmembers maintained sufficient situational awareness during the Incident flight.

3.2.3 Findings relevant to flight operations:

(a) The Commander requested holding in order to obtain sufficient time for both flight crewmembers to understand the problem, make decisions, conduct the necessary failure briefing, and take the necessary action.

(b) The Commander informed the cabin crew manager, and also the Operator's network control center (NCC), of the hydraulic system A failure and the plan to return to the departure airport.

3.2.4 Findings relevant to air traffic control:

(a) The provided holding area to the Aircraft, including the vectoring to landing, did not create significant workload issue(s) for the ATCs to manage departures and arrivals traffic at the departure airport.

3.2.5 Findings relevant to the Operator

(a) There was no time limit applicable to correcting the open deferred defect pertinent to cleaning the main wheel well area.

3.3 Causes

The Air Accident Investigation Sector determines that the cause of the Incident was the rotation of the damaged No. 1 tire inside the left main wheel well that consequently caused damage to some components and lines of hydraulic system A, and the subsequent hydraulic system A pressure loss.

3.4 Contributing Factors to the Incident

The Air Accident Investigation Sector identifies the contributing factors to the Incident as follows:

(a) The intermittent operation of the left alternate antiskid valve, which most probably allowed the two wheels of the left main landing gear to enter the wheel well while still spinning.

(b) The rotating wheel peeled portion of the center tire tread rib of the number 1 wheel did not operate the frangible fitting, resulted in a continuation of the left gear retraction, allowing the number 1 tire peeled portion to damage the hydraulic system A and other parts located in the vicinity.

4. Safety Recommendations

4.1 General

The safety recommendations listed in this Report are proposed according to paragraph 6.8 of *Annex 13 to the Convention on International Civil Aviation*, and are based on the conclusions listed in part 3 of this Report; the Air Accident Investigation sector expects that all safety issues identified by the Investigation are addressed by the concerned organizations.

4.2 Safety Action

Following the Incident, the Operator has taken a safety action by ensuring that the contracted tire retreading agencies implement the tire re-tread reliability-based inspection (including shearography) requirements and the acceptance criteria, as suggested by the Aircraft manufacturer and issued through Boeing *Safety Letter 737-SL-32-128-A*.

4.3 Final Report Safety Recommendations

The Air Accident Investigation Sector recommends that:

4.3.1 flydubai

SR09/2018

To include re-treaded tires in its reliability program, and to ensure that on-wing monitoring of nose and main wheel tire pressures is sufficiently robust to ensure TSO specifications for re-tread tire integrity are maintained throughout the tire operational spectrum.

SR10/2018

To establish appropriate mechanisms to ensure that technical washing of the nose and main wheel well compartments is undertaken with sufficient frequency to allow the integrity of aircraft systems to be assessed sufficiently and continuously. In this regards, a policy is to be established not to defer any maintenance corrective actions without proper documented reference.

4.3.2 The General Civil Aviation Authority of the United Arab Emirates

SR11/2018

To ensure that air operators on-wing monitoring of nose and main wheel tire pressures is sufficiently robust to ensure TSO specifications for re-tread tire integrity are maintained throughout the tire operational spectrum.

4.3.3 Boeing

SR12/2018

To carry out a risk assessment exercise on the protection mechanism system of components in the wheel wells considering the functionality of the frangible fitting in a situation of tire damage during gear retraction.

This Report is issued by:

The Air Accident Investigation Sector
General Civil Aviation Authority
The United Arab Emirates

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Appendix 1. List of the Damaged Parts

No.	Description	Part No	IPC Reference
1	APU fuel drain line Bonding jumper clamp	AN735C6, AN735DC6	29-21-52-02
2	Landing gear retention cable (figure A.1)	BACC2A5D00145BB	32-41-41-01
3	1st blade seal upper/lower retainer (figure A.2)	149A7662-19 /149A7662-20	53-14-00-05B
4	Hydraulic line from Port 2 of system A Flight Control Module (figure A.3)	272A4451-1007	29-11-61-07
5	Hydraulic line from Port 5 of system A Flight Control Module (figure A.3)	272A4454-1008	29-11-61-07
6	Hydraulic line and tee fittings of system A Pressure Module of Union 25 (figure A.4)	AS5804T100808	29-11-52-10E
7	Centre wing spar, EMDP A support structure, bracket at left hand side view	271A1112-28	29-11-21-01
8	System A EMDP upper and lower safety cables – Screw (figure A.5)	BACS12GU3K9	29-11-21-07
9	System A EMDP upper and lower safety cables – Clamp (figure A.5)	MS21919WCF4	29-11-21-07
10	System A EMDP upper and lower safety cables – Washer (figure A.5)	NAS1149D0316J	29-11-21-07
11	Power Transfer Unit hydraulic line 17D tee fitting broken (figure A.6)	272A4454-1017 /AS4139T080806	29-21-52-02D
12	Roll attitude inclinometer broken	5002R	28-40-51-01A
13	Roll attitude support bracket assy		
14	APU fuel drain line	346A2305-1	29-21-52-04
15	Forward W/W wing to body fairing support rod	149A7630-11	53-14-00-04A
16	Aft W/W wing to body fairing support rod	149A7630-3	53-14-00-04A
17	Blade seals	149A7661-21, -38, -39, -40, -41, -42, -43, -44, -45, -46, -53, -54, -55, 56, and 58	53-14-00-05B

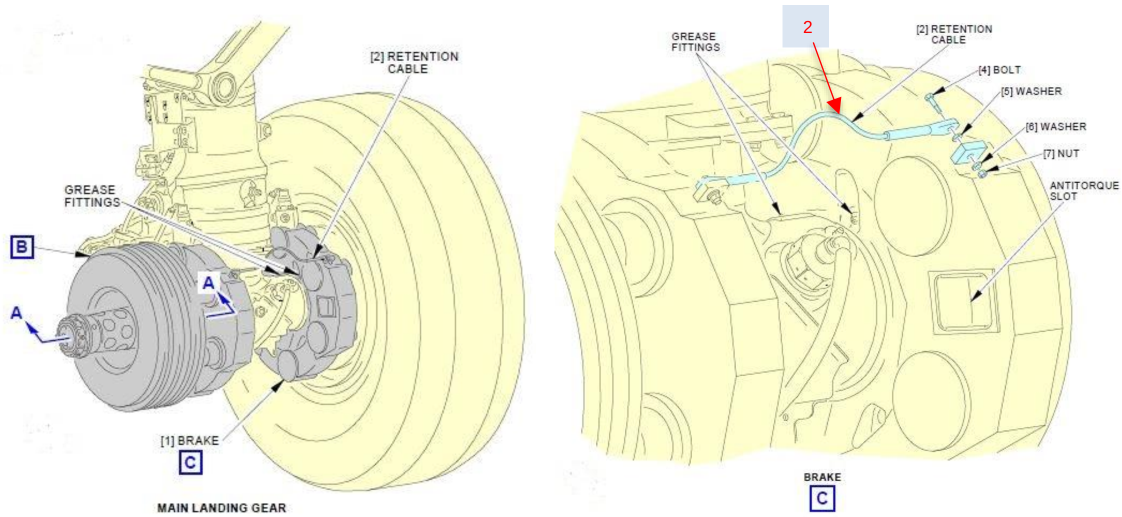

Figure A.1. Left main landing gear [Copyright © Boeing. Reprinted with permission of The Boeing Company]

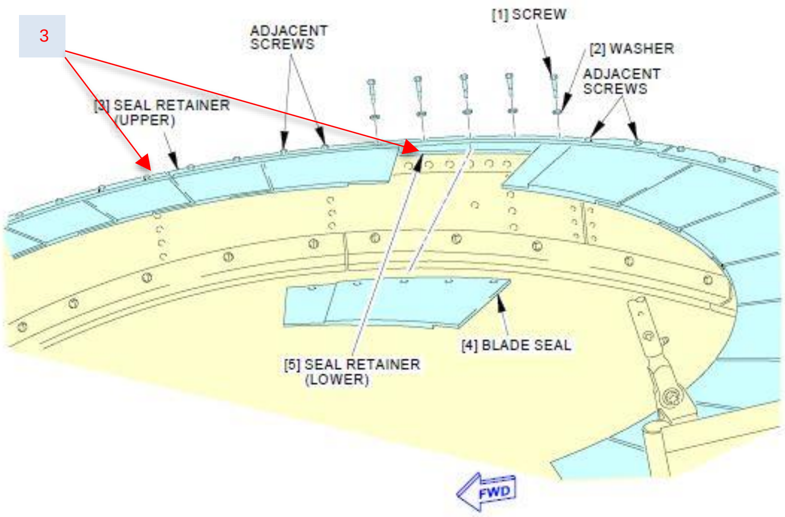

Figure A.2. Main landing gear wheel well blade seal
[Copyright © Boeing. Reprinted with permission of The Boeing Company]

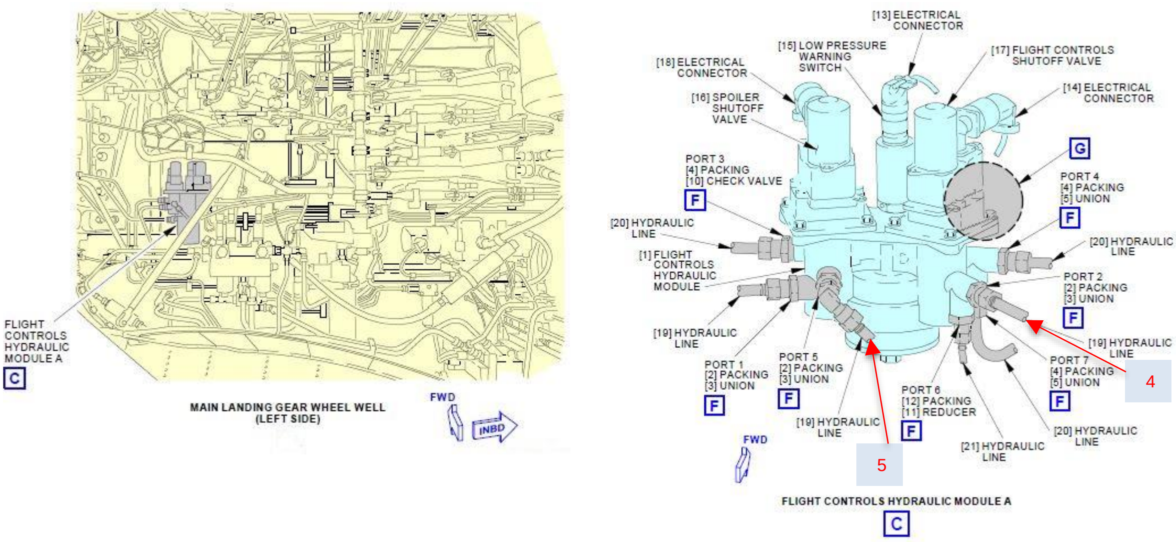

Figure A.3. Hydraulic system A – flight controls hydraulic module A
[Copyright © Boeing. Reprinted with permission of The Boeing Company]

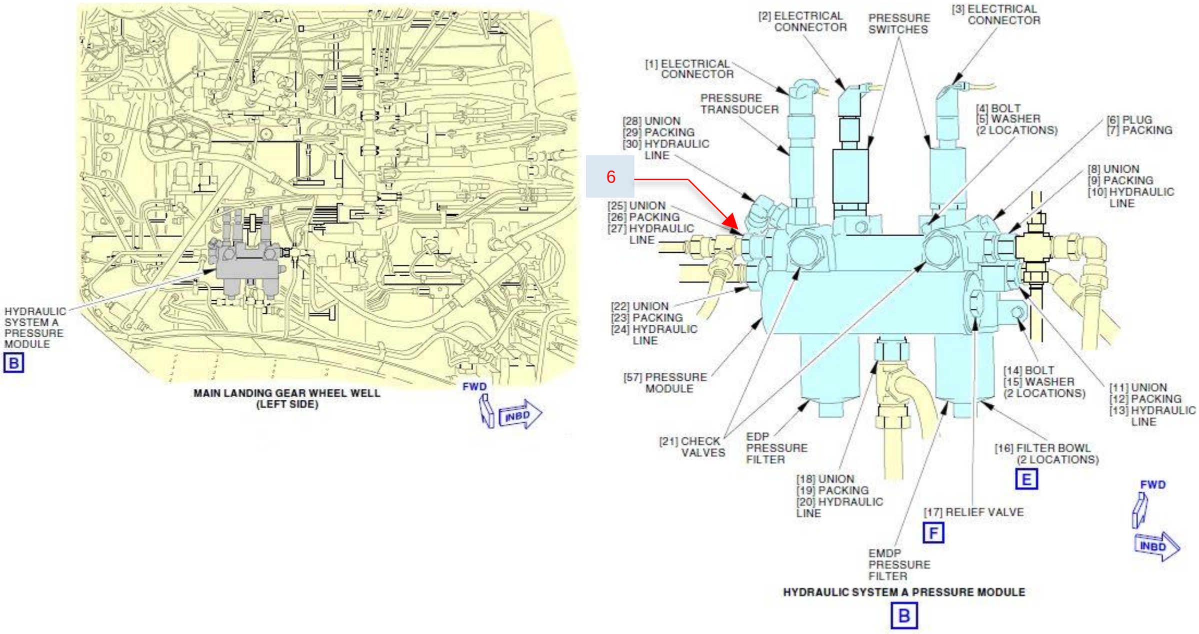

Figure A.4. Hydraulic system A - pressure module

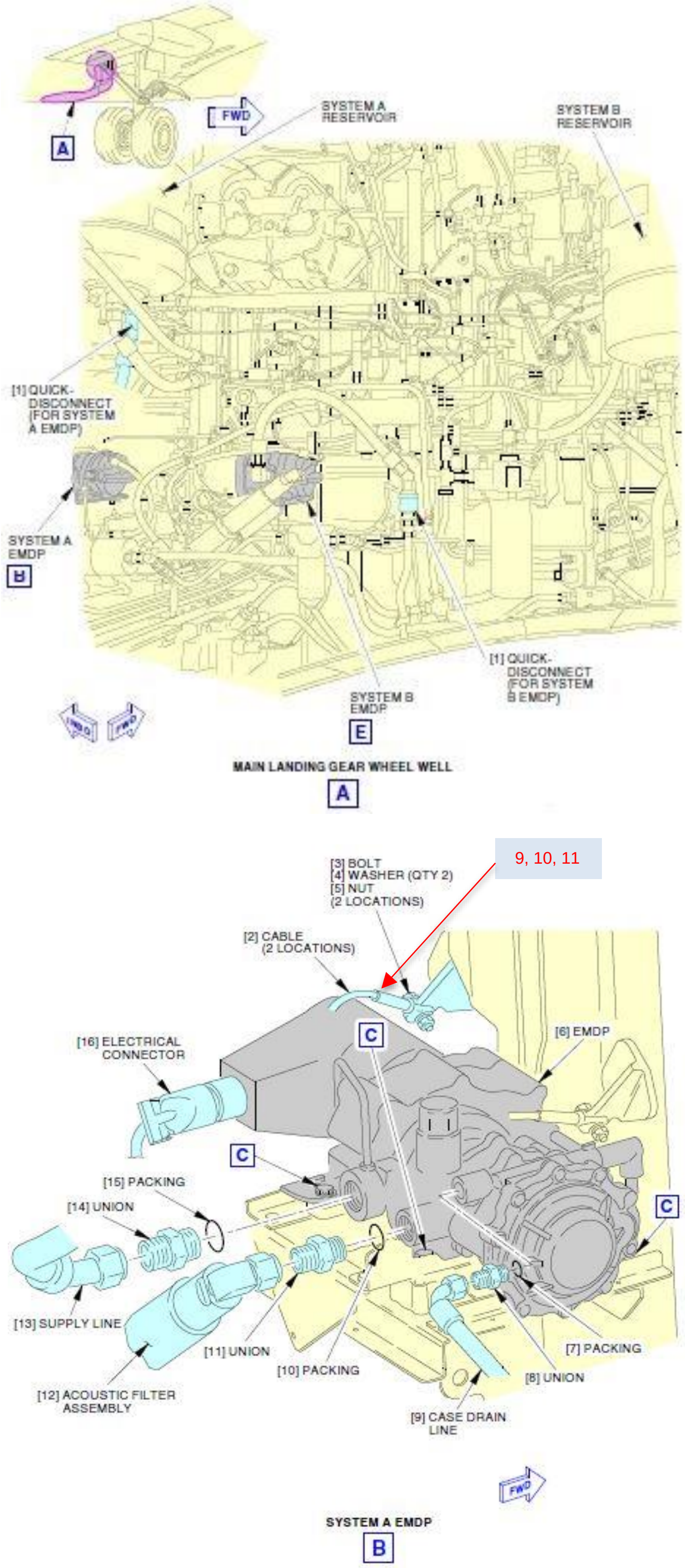

Figure A.5. Hydraulic system A – electric motor-driven pump
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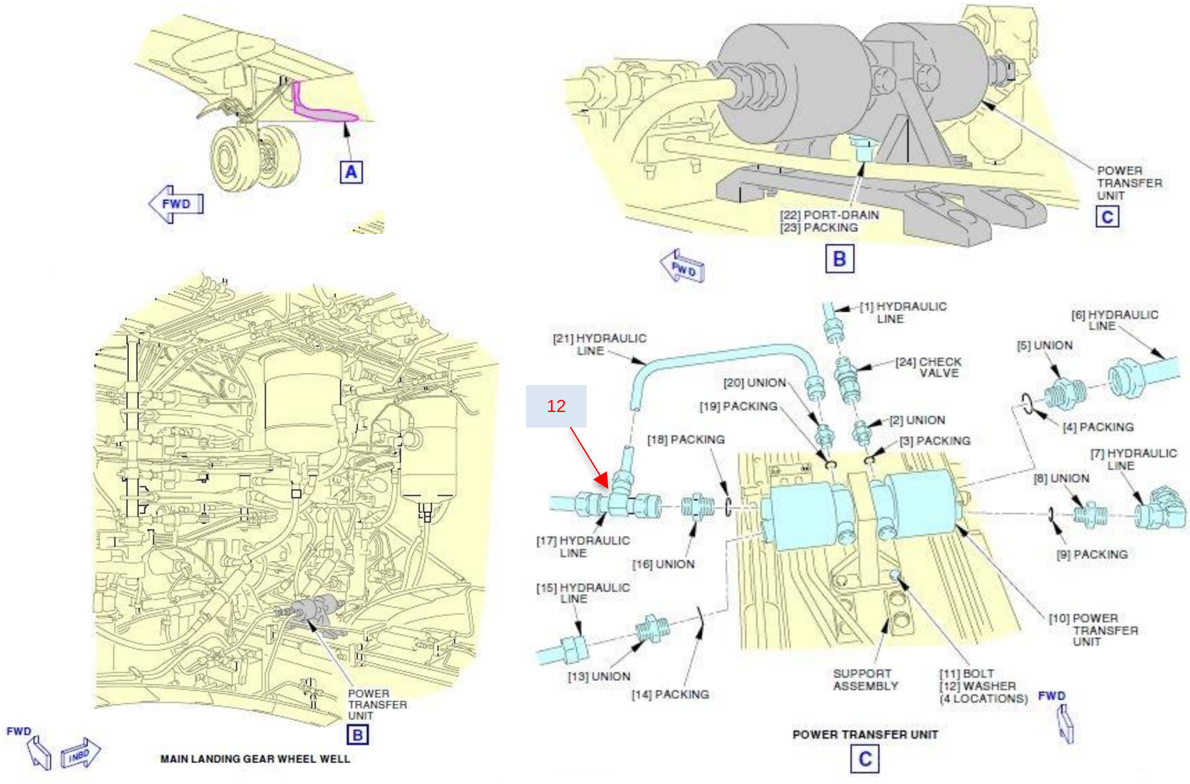

Figure A.6. Hydraulic system A – power transfer unit
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Appendix 2. Detailed Event Descriptions

Relevant read-out and event descriptions from the DFDR and CVR data were examined, as given below. Prior to that, the time between the DFDR and CVR data was synchronized.

The Aircraft lined up on runway 12R for departure at about 0713:43. After take-off clearance was given, the flight crewmembers commenced the take-off at approximately 0715:30.

At 0716:20, nose gear lifted off, and then approximately 3.5 seconds later, LH and RH main gear, almost at the same time, lifted off the ground.

At 0716:26, the Co-pilot mentioned “positive rate”, which then the Commander requested the Co-pilot to retract the landing gear by calling “gear up”.

At 0716:29, all gears were still down, and warning on all gears appeared which means that the landing gear lever was moved to UP position.

At 0716:30, landing gears started retracting. Both left and right brake pressure increased from about 30 to 490 psi, remained between six and seven seconds, and back to the original pressure, 30 psi.

At 0716:33, hydraulic fluid quantity system A started to decrease from 95.5 to 82.5 % full, and continued decreasing to zero thereafter.

At 0716:35, the pressure of hydraulic system A ELEC 2 became low. One second later, at 0716:36, the pressure of hydraulic system A ENG 1 became low. At the same time, the pressure of flight control hydraulic system A also became low, which indicated low hydraulic system A to power ailerons, elevator, and rudder. Consequently, Amber Lights of “LOW PRESSURE – ELEC 2” and “LOW PRESSURE – ENG 1” illuminated on the hydraulic panel, and amber light of “LOW PRESSURE – FLT CONTROL A” illuminated on the flight control panel.

Right gear warning disappeared, which means that the right gear was in up and locked position with the landing gear lever UP. While left main gear and nose gear warnings (red lights of “LEFT GEAR” and “NOSE GEAR” on landing gear panel) remained appeared, which means that left and nose gear were in disagreement with landing gear lever position. In this case, after the transit, the left and nose gears were stuck in an unsafe position.

At 0716:37, the pressure of standby hydraulic system increased to approximately 3,000 psi automatically. This automatic operation activated the standby electric motor-driven pump, opened the standby rudder shutoff valve, and allowed the standby system to power the rudder and thrust reverser. The Master Caution and the “STBY RUD ON” lights on the flight control panel also illuminated in amber. The oil pressure of hydraulic system A was continuing decreasing to almost 0 psi.

At 0716:48, the Aircraft was at approximately 640 feet height while climbing to the selected altitude of 4,000 feet, left main gear came back to down position, and followed by the nose gear after 1 second later. However, the gear warning for both gears still appeared, which means that left and nose gears were down and locked position. The right main gear stayed in Up and locked position, and no gear warning, which means that the landing gear lever was still in the UP position.

At 0717:04, the Commander asked the Co-pilot to inform ATC that the Aircraft had a hydraulic system issue, and requested ATC to provide the Aircraft a convenient area for holding.

At 0717:30, autopilot A was selected and engaged approximately for five seconds

At 0718:08, the Commander requested the Co-pilot to retract the flaps to Up (0 degree).

At 0718:14, flap handle was moved to retract Flaps 1 to 0 deg and consequently brought the flaps to 0 deg. At this point, the airspeed was about 200 KIAS.

At 0718:24, the Commander requested the Co-pilot to engage autopilot B, which then engaged at 0718:29.

At 0718:45, the Commander requested the Co-pilot to go through the non-normal checklist for loss of hydraulic system A. When the Co-pilot was looking for the mentioned checklist, the Commander stated that he would take the radio communication.

At 0719:25, the Co-pilot read the checklist, and together with the Commander, they went through the checklist, and performed the required actions, as mentioned below.

System A FLT CONTROL switch was set to STBY RUD as requested by the Commander. Both switches of System A HYD PUMP (Electric hydraulic pump and engine hydraulic pump switches) were set to OFF.

The non-normal configuration landing distance table will be checked later before the landing, as mentioned by the Commander.

Nose wheel steering switch was set to ALT by the Commander, after read by the Co-pilot.

The plan for manual gear extension was gone through and the gear will be extended manually later before the landing, as mentioned by the Commander.

Autopilot A is inoperative as mentioned by the Co-pilot, and checked by the Commander. Autopilot B is available, which acknowledged by the Commander.

The Co-pilot mentioned that Flight spoilers (two on each wing) are inoperative, which acknowledged by the Commander.

Roll rate and speed brake effectiveness may be reduced in flight, mentioned by the Co-pilot, which then acknowledged by the Commander.

The Co-pilot mentioned that normal landing gear extension and retraction is inoperative, and manual gear extension is required.

Ground spoilers are inoperative. Landing distance will be increased, mentioned by the Co-pilot.

Alternate brakes are inoperative. Normal brakes are available, mentioned by the Co-pilot.

Engine 1 thrust reverser normal hydraulic pressure is inoperative, mentioned by the Co-pilot. The Commander then mentioned that he would not use the thrust reverser since the aircraft is light and it is not necessary to use it, since he would not create unnecessary asymmetric thrust.

Normal nose wheel steering is inoperative. Alternate nose wheel steering is available, which then acknowledged by the Commander.

When both flight crew went through the checklist of loss of Hydraulic System A, ATC Departure contacted the Aircraft, and communicated with the Commander more than once, therefore the flight crewmembers had to break the checklist. However, they continued and finished the checklist after the communication ended with Departure.

At 0723:16, the Commander requested the Co-pilot for the after takeoff checklist. Then both flight crewmembers went through the checklist.

The Co-pilot mentioned:

- Engine bleeds … ON, which were already set ON.
- Packs … AUTO, both ECS were in ON condition.
- Landing gears … UP and OFF. The Co-pilot mentioned that the landing gears were not in UP position, since left and nose gear warnings were still illuminated. The landing gear lever was still at UP position, and he moved it to OFF position.
- Flaps … UP, No lights. Flaps were already set to 0 degrees, and no lights were found.

After takeoff checklist was completed as mentioned by the Co-pilot at 0723:48, which acknowledged by the Commander. Subsequently, the Commander mentioned that he will give the control to the Co-pilot and he will speak to the cabin crew. He then informed the cabin crew about the hydraulic issue and the plan to return to Dubai as a precautionary action.

At 0725:10, the Commander contacted NCC and informed that the Aircraft was at 4,000 feet altitude, about 30 nm from Dubai, and lost the hydraulic system A. He also informed NCC that the flight crewmembers were planning to divert back to Dubai in 10 minutes.

At 0726:41, the Commander mentioned that the landing will be probably an ILS for runway 12L, and the Aircraft will need to go straight. Then, the Commander erased Bahrain arrival plan and changed the arrival plan for landing at runway 12L at OMDB on the FMS.

At 0731:51, the Commander requested the Co-pilot for the descent checklist, and both performed the descent checklist correctly as per standard procedures, as described below.

The Co-pilot mentioned:

- Pressurization …LAND ALT. They left the landing altitude selection as it was, since the Aircraft was planning to return to the original departed airport, OMDB.
- Recall…Checked, which also agreed by the Commander.
- Autobrake… 2
- Landing data……………Vref for flaps 30 = 132 knots, Minimums: 220 feet, mentioned by the Commander, which repeated correctly by the Co-pilot
- Approach briefing is completed, mentioned by the Commander.

At 0732:15, the Commander requested the Co-pilot for the approach checklist, and both performed the approach checklist correctly as per standard procedure, as following:

- Altimeters………1,000 (mbar), mentioned by the Commander. The QNH was as given by Departure.

At 0732:31, the Co-pilot mentioned about reviewing the manual gear extension checklist, which then agreed by the Commander. Then both flight crew reviewed the checklist for Manual Gear Extension, read by the Co-pilot, as the following:

- LANDING GEAR lever……………………………….……OFF
- Manual gear extension handles……………….……….Pull

  The up-lock is released when the handle is pulled to its limit.

  The related red landing gear indicator light illuminates, indicating up-lock release.

- Wait 15 seconds after the last manual gear extension handle is pulled
- LANDING GEAR lever……………………….................DN

After the checklist reading, the Commander mentioned that he understood. Both flight crew were ready for the approach.

At 0733:16, the Co-pilot contacted Departure, mentioned that the Aircraft was ready for the approach runway 12 L, and requested for radar vectoring. Departure subsequently provided radar vectoring. Departure asked whether the Aircraft would expect a long landing, which then answered “negative” by the Commander. The Departure was informed that the flight crewmembers are planning to perform manual extension of the landing gear, which subsequently acknowledged by Departure.

At 0736:45, the Commander requested the Co-pilot to set flap 1, and performed by the Co-pilot.

At 0738:24, Approach instructed the Aircraft to descend to altitude 2,000 feet, which then the selected altitude was set to 2,000 feet, and consequently the Aircraft started to descend.

At 0739:34, the Commander requested the Co-pilot to set the flaps from 1 to 5, which then performed by the Co-pilot. At this point, the airspeed was about 180 KIAS and the Aircraft was descending and passing about 3,030 feet radio altitude.

At 0740:32, the Commander called for the checklist for manual extension of the gear.

The Co-pilot read subsequently the checklist for Manual Gear Extension, as the following:

- LANDING GEAR lever is OFF, and acknowledged by the Commander;
- Manual gear extension handles…………….…….Pull. However, the Commander mentioned that it will be pulled when the Aircraft is about 10 nm from OMDB, which was agreed by the Co-pilot;

Then, the Commander mentioned to the Co-pilot that he will contact NCC, and at 0741:21, the Commander communicated with NCC and informed that the Aircraft will land within 5 minutes. He requested NCC to inform Operator’s maintenance department regarding the oil quantity of hydraulic system A which is zero and the pressure is 10, which then copied by the NCC.

At 0742:19, the Co-pilot continued with the manual gear extension checklist after requested by the Commander. The Co-pilot repeated reading the checklist from the manual gear extension handles, as the following:

- Manual gear extension handles…………….…….Pull.

  The Co-pilot opened the manual extension access door. He mentioned that he would start with the right handle, which thereafter he pulled the right handle. At 0742:37, right gear warning appeared, which means that the right manual gear extension handle had been pulled to its limit, he then released the up-lock. Thereafter, with the same procedure, the nose handle was pulled, and at the end, the left handle. As mentioned before, the warning of the nose and left gear already appeared before pulling the related handles, which means that both gears were not in Up and locked position.

  Then the Commander mentioned that the landing gears are fully down at this time, which means that three green gears lights illuminated.

- LANDING GEAR lever……..DN.

At 0743:16, the Commander requested the Co-pilot to set the landing gear lever to DN, and simultaneously flaps to 15 as well, which then the Co-pilot performed Commander's request.

At 0743:24, all gears warnings disappeared, which means that all landing gears were down and locked.

At 0743:28, the flaps handle was set to 15, and consequently, the flaps were moved and after six seconds, 15 degrees was reached.

At 0744:20, the Commander stated that the glideslope is alive, which was confirmed by the Co-pilot.

At 0744:58, the Commander requested the Co-pilot to set the flaps from 15 to 30. The flap handle was then moved to flaps 30 by the Co-pilot, and consequently, after seven seconds, it brought the flaps to 30 degrees. In the mean time, the Commander mentioned that the glideslope is captured, which means the glideslope (G/S) appeared on the FMA vertical mode. The Commander mentioned and set the selected altitude to 3,000 feet in case go-around is required, which acknowledged by the Co-pilot. At this point, the airspeed was approximately 150 KIAS and the Aircraft was still levelling at the previous selected altitude of 2,000 feet.

At 0745:08, the Aircraft started to descent for the approach runway 12L. The Co-pilot contacted Tower and informed them that the Aircraft was fully established on the glideslope for runway 12L, and at a distance of 6.2 nm. Tower informed the Aircraft that the surface wind is 160 degrees, 5 knots on runway 12L, and cleared the Aircraft to land.

At 0745:52, the Co-pilot mentioned about the landing checklist to be performed, which agreed by the Commander.

Landing Checklist was read by the Co-pilot, as following:

- ENGINE START switches…….CONT, mentioned by the Co-pilot.
- Speedbrake …….. ARMED, mentioned and speedbrake lever set to ARMED position by the Commander.
- Landing gear …….. Down, mentioned by the Commander, which was already down with three green lights.
- Flaps ……… Three zero, (leading edge flaps extended / LE FLAPS EXT on centre forward panel) green light, mentioned by the Commander.

At 0746:33, the Co-pilot mentioned "1,000", which means 1,000 feet above ground level remaining on the descent to the threshold runway 12L. The Commander then acknowledged by mentioning, "checked". The Commander mentioned to have extra knots on the airspeed because of turbulence.

At 0746:41, aural sound "1,000" (1,000 feet above ground level based on radio altitude) was heard.

At 0747:15, the Commander mentioned to fly manual, simultaneously he disengaged the autopilot and auto throttle.

At 0747:18, the Co-pilot called "500" (500 feet to go), which was acknowledged by the Commander.

At 0747:33, aural sound "approaching decision height" was heard.

At 0747:41, aural sound "minimums" (220 feet) was heard. The Commander called "continue landing", which was acknowledged by the Co-pilot.

At 0747:55, radio altitude callout sound "50 ... 40 … 30 … 20 … 10" was heard.

The Aircraft landing on runway 12L at about 0748:03.

The Aircraft vacated the runway to the left through taxiway N8, and continued taxiing to Parking stand E23.

The Aircraft came to stop on Parking stand E23 at 0757:15. Then, the engines were shut down at 0757:47.

Before shutting down, hydraulic system B was normal, and no low pressure warnings were found. Flight recorder switched off when both engines were off.