CARC
هيئة تنظيم الطيران المدني
CIVIL AVIATION REGULATORY COMMISSION

Occurrence - Investigation Report

Right Main Landing Gear Damaged at Landing

Jordan Aviation

Boeing 737-400 JY-JAQ

Kabul International Airport

Kabul, Afghanistan

SFW 502

OAHR-OAKB

10 December 2016

OBJECTIVE

The sole objective of this investigation is to prevent aircraft occurrences and incidents. It is not the purpose of this investigation to assert blame or liability.

This event has been investigated by the Jordan Aircraft Accident Investigation Department (AAID) with assistance from accredited representatives of the United States National Transportation Safety Board (NTSB) and Boeing. The flight data recorder (FDR) data were provided to Boeing for analysis.

The information contained in this Report is derived from the data collected during the ongoing investigation of the Occurrence.

ABBREVIATIONS

AIP	Aeronautical Information Publication
ATC	Air Traffic Control
ATIS	Automatic Terminal Information Service
CARC	Jordan Civil Aviation Regulatory Commission
CVR	Cockpit Voice Recorder
HEA	Herat International Airport / Afghanistan (ICAO code OAHR)
FDR	Flight Data Recorder
FDM	Flight Data Monitoring
FT	Feet (dimension)
IAW	In Accordance With
ICAO	International Civil Aviation Organization
IN	Inch (dimension)
ISAF	International Security Assistance Force
JAV	Jordan Aviation
JORAMCO	Jordan Automotive Maintenance Limited (A Service Provider for JAV)
KBL	Kabul International Airport / Afghanistan (ICAO code OAKB)
M	Meter (dimension)
NOTAM	Note to Airman
OM-A	Operations Manual Part A
PIC	Pilot in Command
QAR	Quick Access Recorder
RFF	Rescue and Firefighting
RWY	Runway
SMS	Safety Management System
TLS	Technical Log Sheet

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1. FACTUAL INFORMATION:

1.1 HISTORY OF THE FLIGHT

On 10 December 2016, JAV Boeing 737-400 Aircraft, registration JY-JAQ, operating a leased scheduled passenger flight SFW 502, on behalf of SAFI Airways under wet lease contract with the later call sign, departed a domestic flight from Herat Airport (OAHR), at 07:00 Z from RWY 36 to Kabul International Airport (OAKB) Afghanistan. At approximately 07:57:45 Z, the Aircraft touched down RWY 29 at Kabul.

The aircraft departed Herat with 164 passengers ,07 Operating Crewmembers and 02 Engineers , Total on board were 173 person.

As the flight approached OAKB, the crew received the automatic terminal information service (ATIS) from OAKB station at 07:45 Z indicating normal weather with visibility of 6 Km, temperature 07 degrees Celsius and wind of 150/07.

The Aircraft was configured for landing with the flaps set to 30, and approach speed selected of 152 knots (VREF + 10) indicated airspeed (IAS). The Aircraft was cleared to approach ILS 29.

The Aircraft was vectored by the radar for RWY 29. Air traffic control cleared the flight to land, with the wind reported to be 190 degrees at 15 knots.

The crew stated that a few seconds after the touchdown, they felt the aircraft vibrating, during which they applied brakes and deployed the reverse thrust. The vibration was followed by the aircraft rolling slightly low to the right. It later came to a full stop left of the runway centre line, resting on its left main landing gear and the right engine, with the nose landing gear in the air. The occurrence occurred at approximately 3,806 ft / 1,160 m past the threshold.

The PIC declared Emergency to the ATC and the cockpit crew initiated an evacuation command from the left side of the aircraft. Evacuation was successfully accomplished with No reported injuries.

Kabul airport RFF reached the occurrence aircraft and observed the smoke coming from right side and immediately deployed their procedures by spraying foam on engine # 2.

The aircraft sustained substantial damage due to the separation of the right main gear resulting on the aircraft skidding on the right engine cowlings. No injuries were sustained by any of the occupants during the occurrence or the evacuation sequence.

Operating crew of the incident flight were called by the Afghani Civil Aviation Authority (ACAA) for interview and medical examination (alcohol and drugs, blood test).

1.2 INJURIES TO PERSONS

No injuries were reported by the occupants of the Aircraft or the ground crew.

Injuries	Flight Crew	Cabin Crew	Other Crew Onboard	Passengers	Total
Aboard	2	5	2	164	173
Fatal	0	0	0	0	0
Serious	0	0	0	0	0
Minor	0	0	0	0	0
Total	0	0	0	0	0

1.3 DAMAGE TO AIRCRAFT

The Aircraft sustained a substantial damage as it can be seen from the pictures, the actual damages and status of the aircraft will determined in the damage report, in addition to the pictures shown below the following estimation for the damage can be summarized with the following;

Right Main Landing Gear was detached from its place; Right trailing inboard flap was detached due to the impact of separated parts of the landing gear. In the absence of the right MLG, the aircraft was skidding on its Engine # 2 hence an additional damage to the underside of the right engine nacelle occurred as it was sliding along the surface during the landing roll.

1.4 OTHER DAMAGE

The separation of the Right Main Landing Gear caused damages to the runway surface and might cause damages to runway lights.

1.5 PERSONNEL INFORMATION

The flight crew was properly qualified and licensed.

1.5.1 PILOT IN COMMAND

Male	Aged 36 years (20-02-1980)
License	Airline Transport Pilot's License PA/T 2744
Aircraft ratings	Boeing 737-300/400
License Proficiency Check date	03-11-2016
Operator Proficiency Check	03-11-2016
Line check	12-05-2016
Medical certificate	Class 1 renewed 20-01-2016 Expiry 31-01-2017
Flying experience	
Total all types	4,800 hours
Total on type	4,800 hours
Last 90 days	180 hours
Last 24 hours	06 hours

The captain of the occurrence flight has joined JAV on 01.10.2005, He started his type rating on B737 on 31.10.2005, he was cleared FO on 15.08.2007 with 250 hrs. His Command upgrade course was on 14.03.2015 ends 28.03.2015 with total of 3592 hrs On the B737. He started line training as PIC on 03.05.2015 and he was cleared on 21.05.2015 with 48.35 hrs. / 26 sectors.

Last PC 03.11.2016, next due 31-05-2017 and his LPC 31-01-2017

Last LC 12.05.2016, next due 31-05-2017

Total of 5078 hours: 201 flying school, 3592 B737 FO, 1285 B737 PIC.

1.5.2 FIRST OFFICER

Male	Aged 29 years (16-11-1987)
License	Airline Transport Pilot's License PA/T 7076
Aircraft ratings	Boeing 737-300/400
License Proficiency Check date	14-10-2016
Operator Proficiency Check	14-10-2016
Line check	22-02-2016
Medical certificate	Class 1 renewed 17-02-2016
Flying experience	
Total all types	3,150
Total on type	3,150 hours
Last 90 days Hours	48 hours
Last 24 hours	06 hours

- The First Officer of the Occurrence Flight has joined JAV 01.08.2010, He started his type rating on B737 01.06.2009, he was cleared FO 29.06.2010 with 70 sectors and 124 hrs. On B737
- Last PC 15.10.2016, next due 30-04-2017. LPC next due 30-10-2017
- Last LC 22.02.2016, next due 28-02-2017
- Total hrs. 3380, 203 flying school, 3177 B737 FO

1.6. AIRCRAFT INFORMATION:

- The aircraft had a valid Certificate of Airworthiness (C of A) and Certificate of Registration (C of R) and was operated within the weight and balance envelop.
- There was no evidence of any defect or malfunction in the aircraft that could have contributed to the accident.
- There was no evidence of airframe failure or system malfunction prior to the accident.

Registration	JY-JAQ	**MSN**	27826
Type	B737-400	**MFG**	08-FEB-1995
Last Weighing Report	22-OCT-2015	**Center Of Gravity**	14.17%
A/C TSN	56805:13	**A/C CSN**	28611

as per JORAMCO Report form# SE/084C

1.6.1 LEADING PARTICULARS

Manufacturer	The Boeing Company
Type	B737-400
Aircraft Serial Number	27826
Year of manufacture	08-Feb-1995
Power plant (Engines)	Two CFM56 3B turbofan engines
Total airframe hours	56805:13 up to 10th December 2016
Total airframe cycles	28,611 up to 10th December 2016
Certificate of Airworthiness	
Date of issue	21-12-2016 Expiry 20-12-2016
Issuing Authority	Kingdom of Jordan Civil Aviation Regulatory Commission
Certificate of Registration No	No. 544 Initial Issue 21-2-2016 Re-Issue 23-04-2015

1.6.2 ENGINES

Engines type: CFM56-3C

POSITION	ESN	LSV DATE	ENGINE TSN	ENGINE CSN	CSO	TSO
#1	724637	25-SEP-2016	56223	39758	240	301
#2	857806	5-SEP-2016	46995	24307	240	301

1.6.3 LANDING GEARS

1.6. 3.1 LANDING GEAR DESCRIPTION

The landing gear consists of two main gears and one nose gear. Each main gear is located aft of the rear wing spar, inboard of the engine nacelles. The nose gear is located below the aft bulkhead of the control cabin. The main and nose gear use air-oil type shock struts to absorb impact on landing and vibrations and shock from movement of the airplane on the ground. Each nose and main gear is equipped with two tire and wheel assemblies. Each main gear wheel is fitted with disc-type hydraulic brakes modulated by an antiskid system and can be controlled by an auto brake system. The main gear is hydraulically actuated to retract inboard into the fuselage. Each main gear is locked in the down position by a folding lock strut and in the up position by an up-lock hook and lock mechanism. Shock strut doors close the opening in the wing for the main gear shock strut and drag strut.

A wheel well seal closes against the main gear tire circumference when the airplane is in flight with gear retracted. The nose gear is hydraulically actuated to retract forward into the fuselage. A lock strut assembly locks the nose gear in the up and down positions. The clamshell-type nose gear doors close to fair with the fuselage contour when the nose gear is retracted and remain open when the nose gear is extended. The main and nose gear manual extension systems are cable- operated to release each gear from the up and locked position and allow the gear to free fall to the down and locked position. Nose wheel steering is provided for aircraft directional control during ground maneuvers. Normal steering is accomplished by using a steering wheel located at the captain's position. A reduced range of steering by rudder pedal is available.

1.6.3.2 MAIN GEAR - DESCRIPTION AND OPERATION

Each main gear consists of a trunnion link, a shock strut, a drag strut, torsion links, a damper, a side strut, and a reaction link. In addition, the right main gear carries ground speedbrake-operating rods and cable. The shock strut assembly is attached to the trunnion link by a pin joint and the two are mounted between the rear wing spar and a trunnion support beam. The shock strut is charged with oil and compressed nitrogen to provide a shock absorbing medium. The main gear axles and the shock strut inner cylinder are machined from a one-piece forging. Replaceable sleeves are assembled over the axles to provide a mounting for wheel bearings and to protect the axles from damage. The reaction link is connected to the shock strut and to the upper end of the side strut.

The main gear trunnion link provides the forward pin of the hinge for main gear retraction and transmits landing gear loads from the drag strut into the airplane structure. The trunnion link is mounted between the shock strut and the rear wing spar. The aft end of the trunnion link is pinned to the shock strut and the forward end pivots in a spherical bearing mounted in the rear wing spar. The top end of the drag strut is attached to a lug on the underside of the trunnion link near the spherical bearing. A pushrod from a bracket on the underside of the trunnion link operates a shock strut door hinged to the wing. The door covers part of the shock strut aperture in the wing when the gear retracts. A swivel fitting for hydraulic lines is mounted on top of the trunnion link. The trunnion link is machined from a high tensile steel forging. The trunnion forward-bearing bolt is designed to fail if the landing gear receives a severe impact, thus minimizing damage to structure.

The main gear torsion links prevent rotation between shock strut inner and outer cylinders without affecting the reciprocating action during normal operation of the strut. The upper torsion link and bottom attachment of the lower drag strut share the same lugs on the shock strut outer cylinder. The lower torsion link is connected to lugs on the inner cylinder. Upper and lower torsion links are joined at the forward ends by a single bolt.

The main gear damper prevents excessive vibration buildup in landing gear during high speed taxi and under heavy braking. The damper is a hydraulic unit containing an actuator, a compensator, and relief and check valves. The main body of the damper is attached to the forward end of the upper torsion link. The actuator piston rod passes through the forward ends of both upper and lower links to provide an apex bolt. Rotary oscillation between the shock strut's inner and outer cylinders is absorbed by the actuator piston displacing hydraulic fluid in the cylinder. The rate of displacement is controlled by the damping orifice in the actuator piston. The compensator is provided to maintain a pressure of 30 to 70 psi on the fluid contained in the actuator.

A 3000 psi relief valve protects the actuator from very high pressures caused by thermal expansion of hydraulic fluid. A 70 psi relief valve protects the compensator from thermal expansion damage. Two check valves are provided to allow hydraulic fluid to enter the actuator and make up for slight leakage or to compensate for fluid contraction. A third check valve permits fluid to enter the unit from the hydraulic system A return and so keeps the damper fully charged with fluid. Bleeder plugs are provided to enable trapped air to be cleared after disconnection of the hydraulic line or when filling an empty unit.

The Status of aircraft landing gears up to the last flight comes as following:

POSITION	P/N	S/N	CURRENT CSN	LAST OVH DATE	TC @OVH
NLG	65-73762-21	CPT2772ET	40537	29-SEP-2009	34598
LH MLG	65-73761-121	MCO4803P2420	34114	8-JUN-2007	23322
RH MLG	65-73761-122	MCO4804P2420	34114	12-JUN-2007	23322

POSITION	NEXT OVH DATE	NEXT TC OVH	REMAINING DAYS	REMAINING CYCLES
NLG	29-NOV-2019	55598	1021	15061
LH MLG	08-JUN-2017	44322	179	10208
RH MLG	12-JUN-2017	44322	183	10208

JY-JAQ Started operation in Afghanistan on 9-Oct-2016, the aircraft was released from "2A" check maintenance and Engines replacement as per Certificate Ref. #: 066/2016, last flight was on 10-Dec-2016. Aircraft flight cycles during this period were 241 Flight Cycle and 3010:40 Flight Hours. The following maintenance was performed during the operation:

- Preflight Checks, latest one done on 10-Dec-2016, at Herat (HEA), Ref. TLS #20568.
- Daily Check, Latest one dated 10-Dec-2016, at Kabul (KBL) Ref. TLS #20566.
- Weekly check; latest one dated 27-Nov-2016 at Dubai (DXP), REF TLS #17883.
- "3A" check dated 27-Nov-2016 Kabul (KBL) – Certificate Ref. #081/2016.

Rectification of discrepancies performed during the operation:

- 11-Sep-16 left hand nose wheel worn out: the same nose wheel assembly was replaced IAW AMM 32-45-21/401
- 11-Sep-16 right hand nose wheel worn out: the same nose wheel assembly replaced IAW AMM 32-45-21/401

- 11-Sep-16 #2 main wheel side wear: the same #2 main wheel assembly was replaced IAW AMM 32-45-11/401
- 15-Sep-16 side wear on #4 tire: #4 main wheel assembly was replaced IAW AMM 32-45-11/401
- 19-Sep-16 during walk around check found brake #4 worn out: the same main wheel brake #4 replaced IAW AMM 32-41-41/401

DATE	DISCREPANCIES	RECTIFICATION	P/N ON	S/N ON
11-Sep-16	L/H NOSE WHEEL WORN OUT	L/H NOSE WHEEL ASSY REPLACED IAW AMM 32-45-21/401	3-1438-1	0958
11-Sep-16	R/H NOSE WHEEL WORN OUT	R/H NOSE WHEEL ASSY REPLACED IAW AMM 32-45-21/401	3-1438-1	1089
11-Sep-16	#2 MAIN WHEEL SIDE WEAR	#2 MAIN WHEEL ASSY REPALCED IAW AMM 32-45-11/401	3-1484	0560
15-Sep-16	SIDE WEAR ON #4 TIRE	#4 MAIN WHEEL ASSY REPLACED IAW AMM 32-45-11/401	3-1484	0355
19-Sep-16	DURING WALK AROUND CHK FOUND BRAKE #4 WORN OUT	MAIN WHEEL BRAKE #4 REPLACED IAW AMM 32-41-41/401	2-1474-7	4562
25-Sep-16	#3 MAIN TIRE HAS WORN OUT & CUTS	#3 MAIN WHEEL ASSY REPLACED AS PER AMM 32-45-21/401	3-1484	0091
02-Nov-16	DURING P/F CHK FOUND #2 MAIN WHEEL NORMAL WEAR	#2 MAIN WHEEL REPLACED BY SERV. NEW ONE IAW AMM 32-45-11/401	3-1484	0305
04-Nov-16	DURING DAILY CHK FOUND MAIN WHEEL #4 WORN OUT	#4 MAIN WHEEL REPLACED BY SERVICEABLE ONE IAW AMM 32-45-11	3-1484	0149
04-Nov-16	DURING DAILY CHK FOUND L/H & R/H NOSE WHEELS WORN OUT	L/H & R/H NOSE WHEELS REPLACED BY SERVICEABLE WHEELS AS PER AMM 32-45-21	3-1438-1	L/H 0710 R/H 2121
17-Nov-16	DURING P/F CHK FOUND #3 MAIN WHEEL WITH NORMAL WEAR	#3 MAIN WHEEL REPLACED BY SERVICEABLE ONE AMM REF 32-45-11/401	3-1484	0317
20-Nov-16	TIRE #1 TO BE REPLACED	TIRE #1 REPLACED IAW AMM 32-45-11	3-1484	0628

1.7 METEOROLOGICAL INFORMATION

Departure

- OAHR, Herat (Afghanistan)
- WMO index: 40938
- Latitude 34-13N. Longitude 062-13E. Altitude 964 m.
- METAR/SPECI from OAHR

201612100755 METAR OAHR 100755Z 11001KT 9000 BKN030 07/02 Q1020 RMK BLU=
201612100855 METAR OAHR 100855Z VRB03KT 9000 SCT030 07/02 Q1019 RMK BLU=
201612100955 METAR OAHR 100955Z 05001KT 9999 SCT020 07/00 Q1018 RMK BLU=

Destination

- OAKB, Kabul Airport (Afghanistan)
- WMO index: 40948

- Latitude 34-33-00N. Longitude 069-13-00E. Altitude 1791 m.
- METAR/SPECI from OAKB

201612100750 METAR OAKB 100750Z 15009KT 6000 BKN040 09/03 Q1015 NOSIG RMK WHT WHT=
201612100850 METAR OAKB 100850Z 21016G31KT 8000 SCT080 10/01 Q1014 NOSIG RMK BLU WHT=
201612100950 METAR OAKB 100950Z 19012KT 9999 SCT050 11/M00 Q1014 NOSIG RMK BLU BLU=

The Meteorological Terminal Air Report (METAR) issued by NATO International Security Assistance Force Metrology Office at Kabul Airport (ISAF KAIA MET Office), on 10 December 2016, shows the weather condition for 0750 as follows:
201612100750 METAR OAKB 100750Z 15009KT 6000 BKN040 09/03 Q1015 NOSIG RMK WHT WHT=
The METAR indicated that the wind was from 150°(southeast) at 9 knots, Visibility is 6,000 m (19,700 feet), Broken clouds at 4,000 feet (1.200 meter), Temperature 9°C , dew point 3°C , barometric pressure adjusted to sea level (QNH) 1015 hPa (29.97 inHg), the METAR report included a remark which is usually used for military aerodromes; the WHT WHT remark means that the minimum reported visibility was 5000-7999 m.

1.8 AIDS TO NAVIGATION

The aids to navigation available for approach to runway 29 at Kabul Airport are an instrument landing system (ILS), distance measuring equipment (DME), and RNAV. The Aircraft navigation system consisted of inertial reference system IRS very high frequency omnidirectional range (VOR) receivers, DME receivers, ILS receivers, air traffic control transponder, weather radar, and flight management system (FMS) with two flight management computers (FMC) and two automatic direction finders (ADF). The Aircraft was also equipped with an autopilot flight director system.

1.9 COMMUNICATIONS

All communications between air traffic control and the flight crew were recorded by the aircraft cockpit voice recorder for the duration of the Occurrence flight and were made available to the Investigation.

1.10 AERODROME INFORMATION

The ICAO code for Kabul International Airport is OAKB.
Airport is about half mile (1 Km) north northeast of Kabul City and just west of Khwaja Rawash village, 25 miles (40 Km) south of Bagram airfield, and 68 miles (110 Km) west of Jalalabad.
Kabul Airport relies at present, in many of its services and facilities, on equipment and personnel provided by the military users of the airport. This equipment will be replaced by new equipment and related buildings and installations. These include air traffic control and telecommunication installations, meteorological equipment and facilities, fire and rescue vehicles and station, standby power supply, airport maintenance equipment, etc.

The Ministry of Transport and Civil Aviation's plans for the development of Afghanistan's infrastructure and essential services include the rehabilitation of Kabul Airport to international standards. With this objective in mind, the International Community, and NATO-ISAF in particular, have been taking charge of Kabul Airport and assisting the Ministry of Transport and Civil Aviation in overseeing the implementation of necessary rehabilitation and upgrading works to attain international standards, prior to handing it over to the Afghan authorities.
Hills and mountains reaching above 10500 feet (3200 m) within 15 miles (24 km) of airport. Airfield is constructed in marsh area with level of water table about 3 feet below surface. Area is drained by a series of canals which empty into a well located north of runway. Water is pumped from well to drainage ditch and flows to northeast.

Kabul airport is known for wind shear on final approach for both runway ends.
FOD hazard is known and evident on all runway shoulders according to airport information provided by Afghan Civil Aviation Authority on their official website and AIP.

Location Information for OAKB Coordinates:
N34°33.95' / E69°12.75'
Elevation is 5877.0 feet MSL .
Magnetic Variation is 2° East
Airport Communications
KABUL Approach: 131.6
KABUL Arrival: 132.5
KABUL Ground Control: 120.3
KABUL Tower: 129.40
Runway 11/29

Runway	Runway 11	Runway 29
Dimensions:	11483 x 164 feet / 3500 x 50 meters	
Surface:	Hard	
Coordinates:	N34°34.23' E69°11.65'	N34°33.67' E69°13.84'
Elevation:	5873 ft	5877 ft
Runway Heading:	107°	287°

OAKB/KBL
KARZAI INTL

JEPPESEN 2 DEC 16 (11-1)

KABUL, AFGHANISTAN
ILS Rwy 29

ATIS	*KABUL Arrival	KABUL Approach (R)	KABUL Tower	Ground
130.15	132.5	131.6	120.6	125.4

LOC	Final Apch Crs	GS	ILS DA(H) (CONDITIONAL)	Apt Elev 5877'
IAKW 110.5	285°	HIGEL 9800'(3927')	6193'(320')	THR 5873'

MSA KBL VOR: 17,500' (090°–180°), 16,100' (180°–360°), 16,800' (360°–090°)

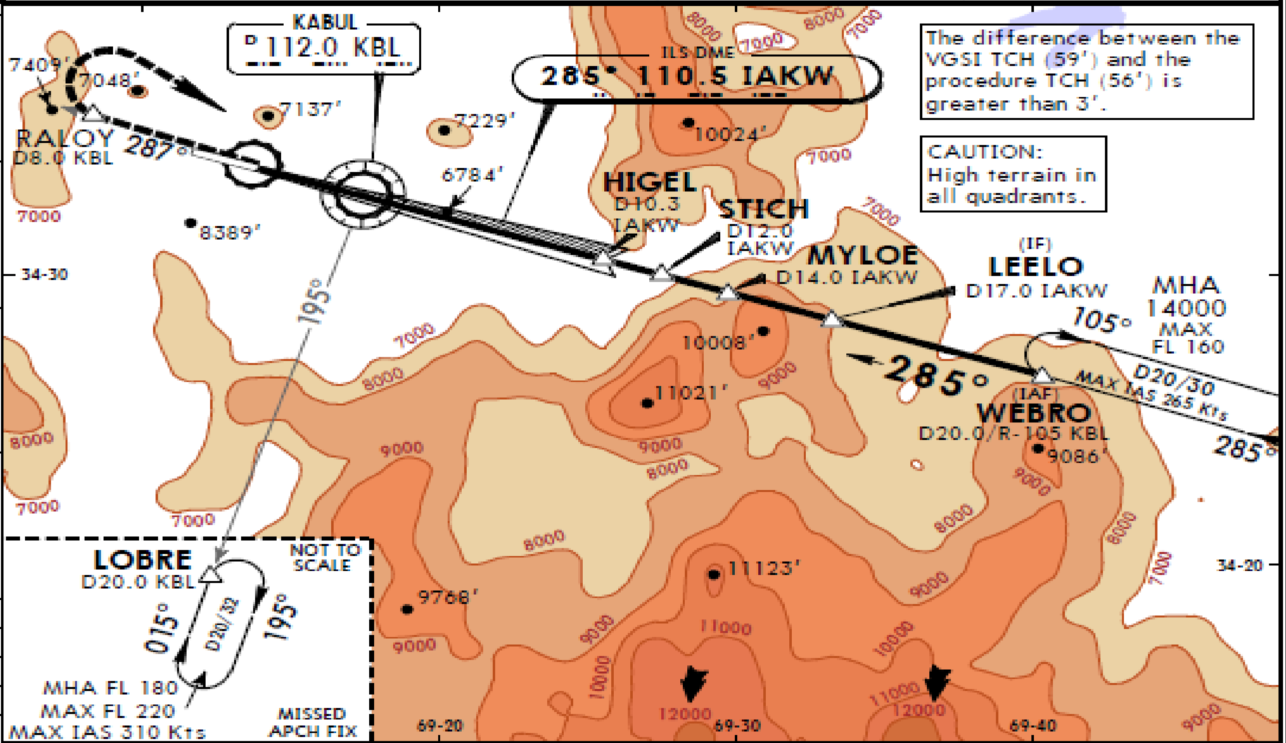
MISSED APCH: Climb to FL 180 via KBL R-287 to RALOY, then turn RIGHT direct KBL. Cross KBL and proceed on KBL R-195 to LOBRE and hold. Continue climb-in-hold to FL 180.

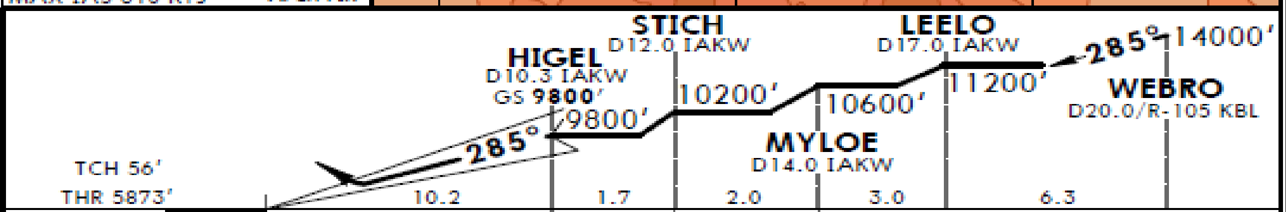
CAUTION: Missed Apch Minimum Climb Rate to 18000' 200'/NM. 350'/NM required for lower DA(H).

	Gnd speed-Kts		60	120	180	240	300
200'/NM	V/V	fpm	200	400	600	800	1000
350'/NM	V/V	fpm	350	700	1050	1400	1750

Alt Set: hPa THR Elev: 197 hPa Trans level: FL 160 Trans alt: 14000'

1. **ATC RADAR required.** 2. CAUTION: Do not begin descent unless established on both localizer and glidepath. 3. CAUTION: Execution of missed approach at DA(H) is essential. 4. EMERG SAFE ALT 100 NM 21700' 5. Ground movements and some parked acft may affect ILS signals for Rwy 29.





Gnd speed-Kts	70	90	100	120	140	160
GS 3.50°	434	557	619	743	867	991

PAPI ALSF-I — FL 180 via KBL 112.0 R-287 — RALOY

Military

STRAIGHT-IN LANDING RWY 29

	ILS: Missed apch climb gradient mim 350'/NM to 18000' DA(H) 6193'(320') FULL	ALS out	ILS: Missed apch climb gradient mim 200'/NM to 18000' DA(H) 7052'(1179') FULL	ALS out	LOC (GS out)
A, B, C, D	750m	1400m	4900m	5600m	NOT AUTHORIZED

CIRCLE-TO-LAND

A, B, C, D	NOT AUTHORIZED

CHANGES: WEBRO altitude.

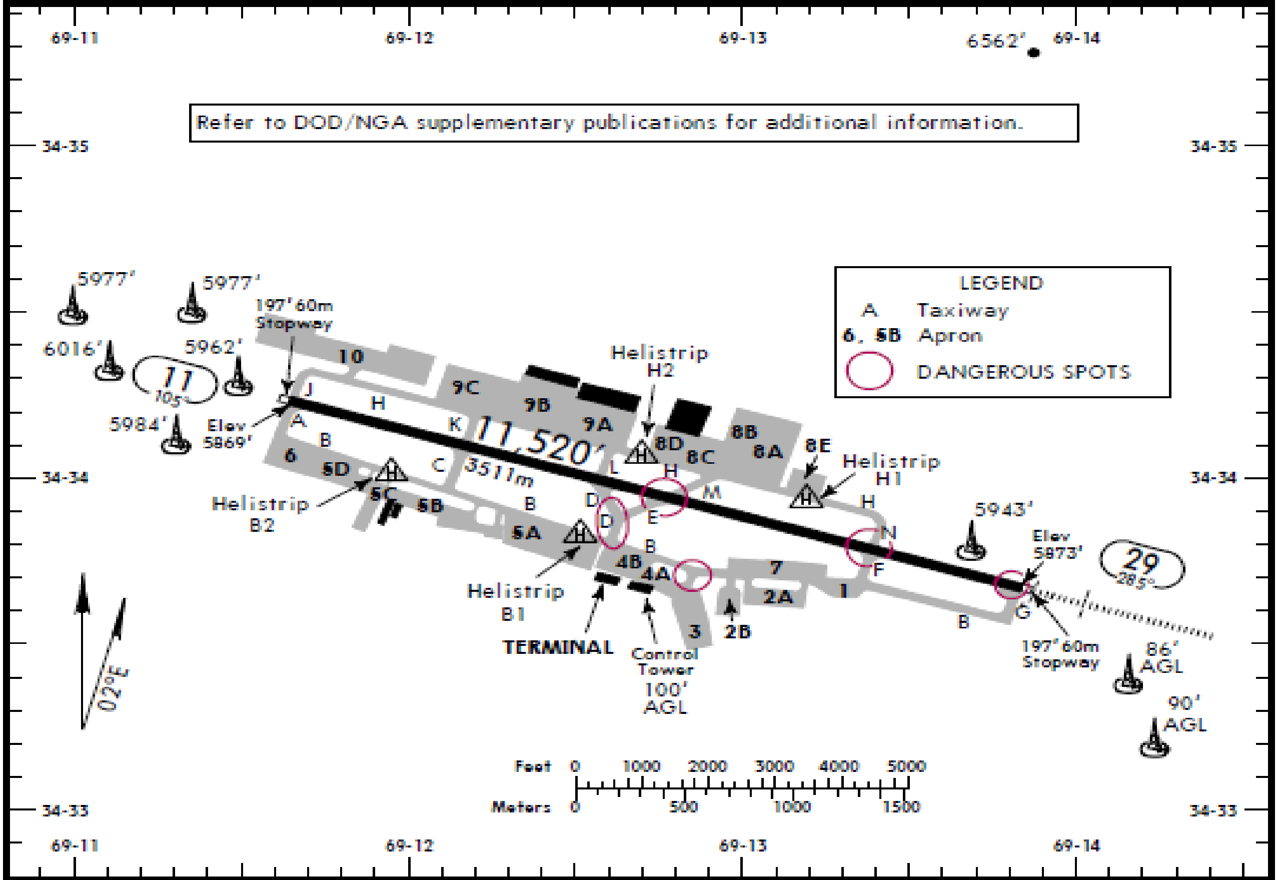
OAKB – Kabul, Afghanistan – ILS 29

OAKB/KBL
Apt Elev **5877'**
N34 34.0 E069 12.7

JEPPESEN
2 DEC 16 (10-9)

KABUL, AFGHANISTAN
KARZAI INTL

ATIS	*KABUL Delivery	KABUL Ground	Tower
130.15	128.1	125.4	120.6



ADDITIONAL RUNWAY INFORMATION

RWY		USABLE LENGTHS LANDING BEYOND Threshold	Glide Slope	TAKE-OFF	WIDTH
11	HIRL (60m) HIALS ❶ PAPI				164' 50m
29	HIRL (60m) ALSF-I ❷ PAPI ❸		10,609' 3234m		

❶ Configuration unknown. ❷ SFL are out of service. ❸ Unusable beyond 5° Right of RCL.

PREFERENTIAL RUNWAY

When tailwind component is less than 10 KT sustained and rwy surface is dry or wet with braking action good, use rwy 29.

TAXI PROCEDURES

For operations between SS and SR on apron 3, Follow-me and marshaller guidance is required.
Max taxi speed shall not exceed 16 KT.
Only after vacating the rwy quickly until the entire acft is clear of holding position, pilot shall immediately report "Rwy vacated".

Military

TAKE-OFF ❶

	Rwy 11		Rwy 29	
	With minimum climb of 385'/NM to 11000'		With minimum climb of 444'/NM to 9900'	
	Adequate Vis Ref	STD	Adequate Vis Ref	STD
1 & 2 Eng	400m	1600m	400m	1600m
3 & 4 Eng		800m		800m

❶ Diverse departure not authorized.

CHANGES: None.

OAKB – Kabul, Afghanistan – Aerodrome Chart

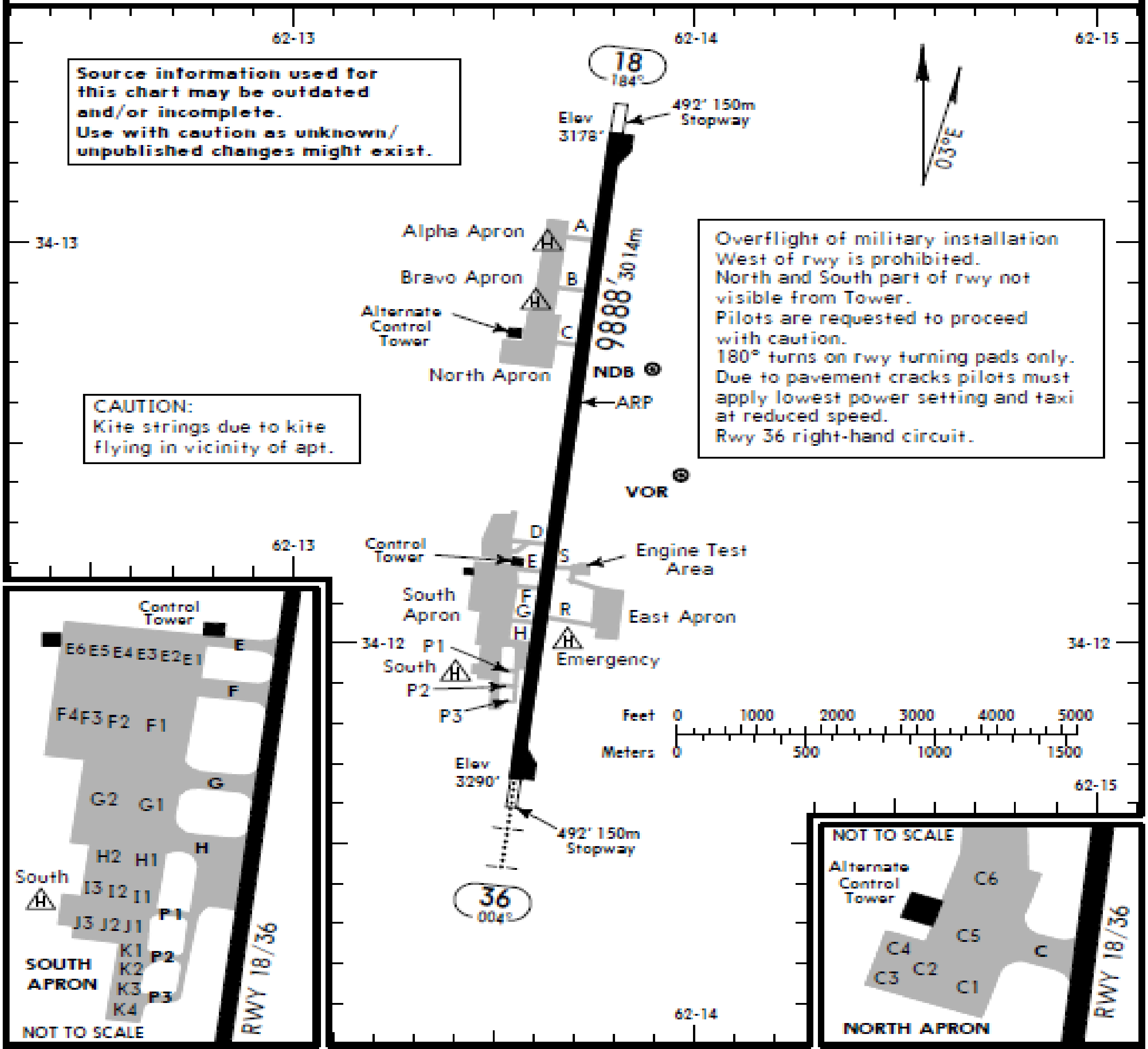
OAHR/HEA JEPPESEN HERAT, AFGHANISTAN

Apt Elev **3290'** — 9 OCT 15 — **Eff 15 Oct** — 10-9 — HERAT

N34 12.6 E062 13.7

*HERAT Tower

123.350 126.450



ADDITIONAL RUNWAY INFORMATION

RWY		USABLE LENGTHS — LANDING BEYOND Threshold	USABLE LENGTHS — LANDING BEYOND Glide Slope	TAKE-OFF	WIDTH
18	HIRL (60m)				148' 45m
36	HIRL (60m) ALS PAPI-L (angle 3.0°) ❶				

❶ on request.

TAKE-OFF

AIR CARRIER (JAA)

All Rwys

	LVP must be in force RCLM (DAY only) or RL	RCLM (DAY only) or RL
A	250m	400m
B	250m	400m
C	250m	400m
D	300m	400m

CHANGES: Arresting gears withdrawn. Note.

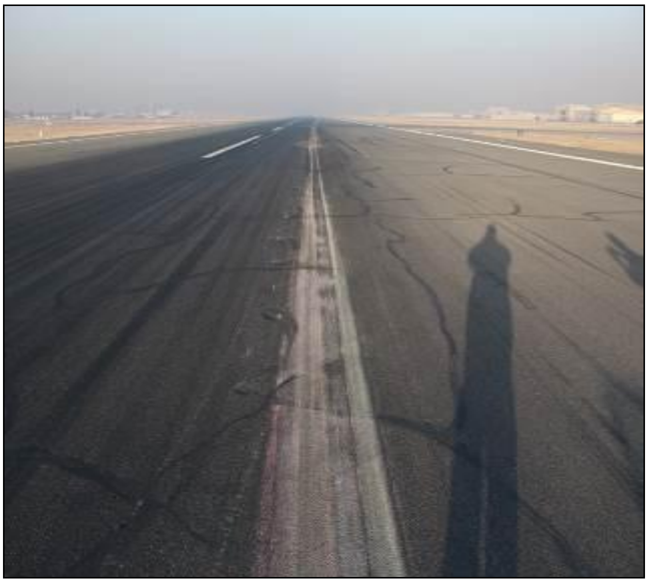
OAHR – Herat, Afghanistan – Aerodrome Chart

1.11 FLIGHT RECORDERS

The aircraft was fitted with a solid-state Cockpit Voice Recorder (CVR), Allied Signal, Part Number 980-6020-001, Serial Number 1321, and a solid-state memory Flight Data Recorder, Allied Signal, Part Number 980-4700-001, and Serial Number 1480.
Both recorders were removed and sent for analysis by the Jordan Civil Aviation Regulatory Commission to the investigation office of UAE CAA in Abu Dhabi. Flight data analysis will be detailed in the analysis part of this report. And lately the raw data has been sent to the Boeing for in depth analysis.

1.12 WRECKAGE AND IMPACT INFORMATION

The point of touchdown of the Aircraft with the runway was approximately 1,067 meters from runway 29 threshold, approximately 240 meters before TWY M, the RWY approximate remaining distance was measured to be 2,351 meters from the point of touch down to the point at RWY 11 threshold. The Aircraft came to rest at 326 meters from runway 11 threshold.
At touchdown, the right main landing gear suffered a damage that resulted with the detachment of the assembly. The aircraft slid on the right engine until it came to complete stop.
As the right main landing gear detached from its position, the tyres and detached components resulted in damage to the fuselage and right inboard flaps, which was detached also as a result of the impact with parts of the landing gear assembly.
The right engine suffered significant damage to impact with ground.
The aircraft was removed from the runway to one of the adjacent aprons.
The tyres suffered damage no several locations, the tires were showing damage on the side walls.



The aircraft's right-hand main landing gear inboard tire shaking tire marks occurred for a distance of approximately 400 - 500 m, at this time the right main landing gear had detached and was dragged away, causing the right wing to drop. There was evidence of runway surface damage at almost similar intervals of appearing together with the hard tire contact marks, and this may also indicate that both tires were damaged after the shimmy damper failed and the oscillations were occurring.
No map diagram for the accident scene was performed by the Afghan Authority to show the wreckage distribution, and all damaged parts of the aircraft were collected and stored at the civil defense hangar.

1.13 MEDICAL AND PATHOLOGICAL INFORMATION

As stated by the flight crew "Post-occurrence blood tests did not reveal psychoactive materials that could have degraded the crew performance".

1.14 FIRE

Fire warning from engine number 2 was dispensed, some smoke was seen around engine number 2, and engine drill was accomplished including engine fire extinguishers activation, at the end of the landing run at KBL Airport Fire and Rescue Service vehicles had been pre-positioned close to the runway, both behind and ahead of where the aircraft came to rest. A foam blanket was applied to the ground and the right side of the aircraft.

1.15 SURVIVAL ASPECT

An evacuation of the passengers was carried out after the instruction of the PIC to evacuate the Aircraft through the L1 and L2 exits, Cabin crew managed to evacuate all the passengers without any injuries in less the one minute.

1.16 TESTS AND RESEARCHS

No laboratory tests were made after this occurrence as the wreckage of the damaged components is under the custody of US army at Kabul airport.

1.17 ORGANIZATIONAL AND MANAGEMENT INFORMATION

The JY-JAQ is owned by Jordan Aviation (JAV), JAV is Jordanian airlines and is privately owned, has its headquarters in Amman, Air Operator Certificate (AOC) was obtained in October 2000 and commenced operation in November 2000. JAV is a member of the International Air Transport Association (IATA), and the Arab Air Carriers Organization (AACO).

Between the years 2001 and 2003 JAV activities were on charter contracts with the United Nation’s peace keeping troops. During the years 2005 and 2007, JAV operated programmed charter flights from King Hussein International Airport to destinations in the region like Kuwait, Doha, Alexandria, and Bahrain. JAV's charter routes now cover the Globe.

In 2006 JAV started leasing its aircraft to other Arab and foreign airlines on Dry Lease basis especially during the peak periods. On that same year JAV completed the IATA Operational Safety Audit (IOSA).

JY-JAQ was wet leased to Safi Airways for the period of 9-10-2016 to 31-12-2016, the lease is an ACMI lease that means JAV will provide the aircraft, crew, maintenance and the insurance. The aircraft was positioned to Kabul (KBL) on 09-10-2016, the destination flown were Herat International Airport (HEA, OAHR), Dubai International (DXB, OMDB) and Indira Gandhi International (DEL VIDP)

Safi airways was founded in the year 2006, it's an Afghanistan privately owned international airline. It is owned by Safi Group of companies.

The airline has its headquarters in Kabul, Afghanistan and an administrative office in Dubai.

2. ANALYSIS

According to the DFDR & CVR flight data records and operating crew statements, in addition to the factual information were collected during the course of this investigation including maintenance records, the accident site, the wreckage of the Right Main Landing Gear and BOEING Company Analysis from the DFDR , a ground track analysis was generated to show the airplane path during the approach and landing rollout.

An Aviation Routine Weather Report (METAR) was posted at 12:20 PM local time; the landing at KBL occurred at 12:27 PM, just 7 minutes after the post. The METAR stated the following:

OAKB 100750Z 15009KT 6000 BKN040 09/03 Q1015 NOSIG RMK WHT WHT

The METAR report indicates that the winds were out of the south-southeast at 9 knots with a visibility of 3.7 miles and a ceiling of broken clouds at 4000 feet. The wind data resolved into components referenced to the runway heading (true heading = 287 degrees) resulted in an approximate 7-knot tailwind and 6-knot left crosswind.

The CVR data show that the latest weather information provided by ATC before landing was 190/15 Knots.

2.1 APPROACH AND GROUND TRACK ANALYSIS:

The FDR data show the airplane descending from 1000 feet radio altitude (RA) configured for a flaps 30 landing with the speedbrakes armed, the autopilot disengaged by time 3810 seconds, and the autothrottle engaged through touchdown (Figure 1). The airplane was on approach to Runway 29 at KBL (verified by the recorded magnetic heading) and landed at a gross weight of 123,100 pounds (LB) [the maximum design landing weight is 123,899 LB]. Based on the landing weight and flap position, the landing reference speed (VREF) should have been approximately 142 knots. The approach speed was not recorded; however the computed airspeed was maintained at approximately 162 knots during the final approach with the autothrottle engaged which indicates that the approach speed was most likely VREF+20. From 900 feet RA until 75 feet RA, the descent rate (negative calculated vertical speed) was maintained at above 1000 feet/minute (fpm) with an average descent rate of 1250 fpm and maximum descent rate of 1400 fpm at time 3828 seconds. The glideslope deviation indicated the airplane was below the beam during the approach and the localizer deviation indicated that the airplane was either on or slightly right of the runway centerline (Figures 1 and 2). The calculated wind data were comparable to the airplane recorded ship system winds in magnitude, with more variation in the direction (Figure 2). However, both wind data sources indicate that the airplane was in a left quartering tailwind. Beginning at about time 3740 seconds at approximately 2000 feet RA, just as the airplane descended to capture the glideslope (not shown), the atmospheric conditions became turbulent with increased perturbations in computed airspeed, vane angle of attack, normal load factor and lateral acceleration, along with increased control wheel and column inputs to maintain the desired attitudes.

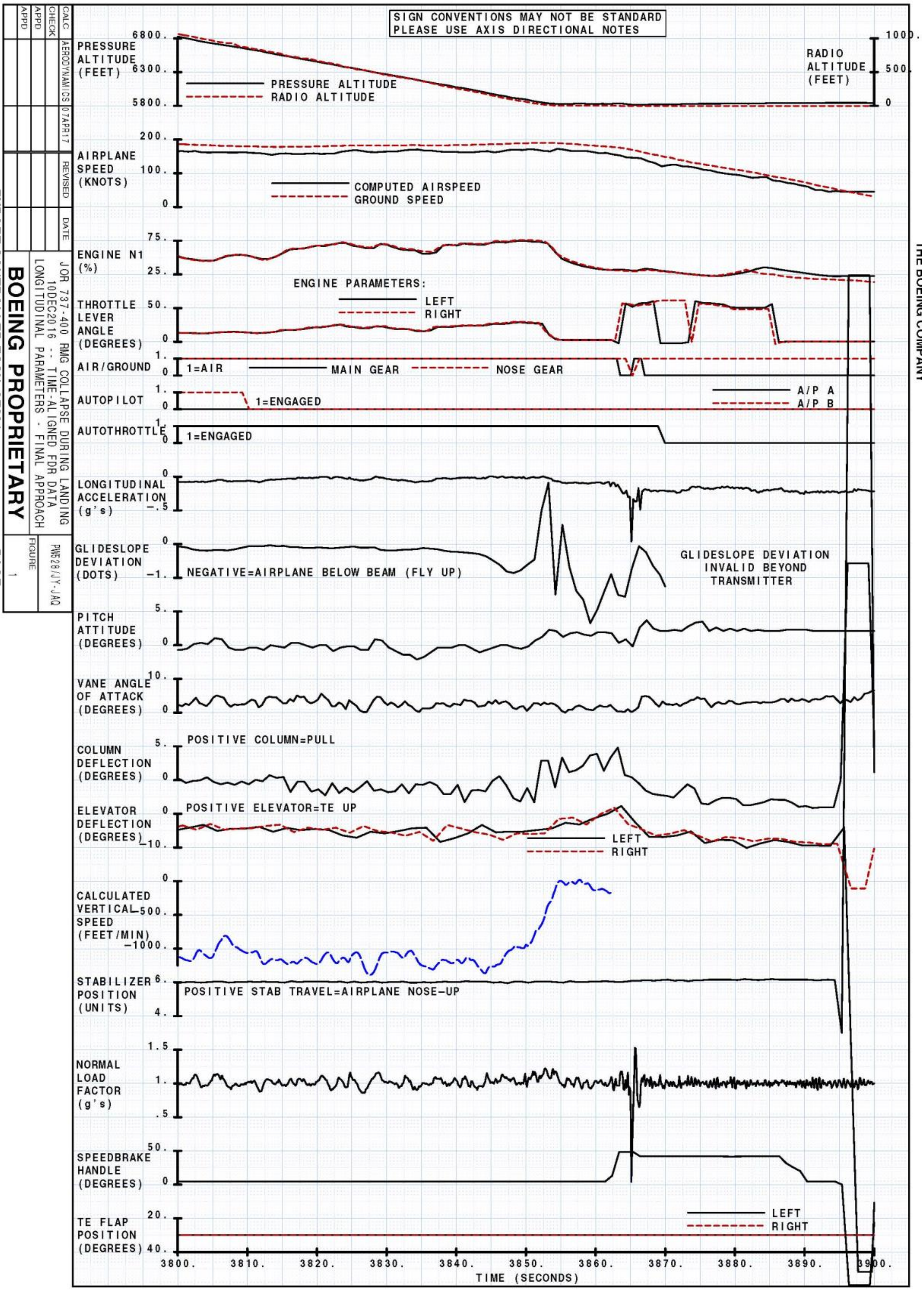
During the approach, the airplane experienced an average 7-knot tailwind with an approximate 15-knot left crosswind component. At about 35 feet radio altitude, an airplane nose-up column input was commanded around time 3851 seconds initiating landing flare, and the sink rate began to decrease (Figure 3). The airplane was in a left crab (negative drift angle) which is consistent with a left crosswind, which was nearly removed at touchdown with right rudder pedal input (Figure 4). Based on a change in character of the longitudinal acceleration, the main gear contacted the runway at time 3862 seconds at a computed airspeed of approximately 158 knots (VREF+16) and a ground speed of 178 knots (Figure 3). The main gear air/ground discrete parameter changed state from AIR to GROUND just after time 3863 seconds. The descent rate at the center of gravity (CG) when the main gear transitioned to GROUND state was 3.0 feet/second (fps). Touchdown occurred at a pitch attitude of approximately 0.4 degrees nose-up and a bank angle of approximately 1 degree to the right (Figures 3 and 4). The closure rate (negative calculated vertical speed) of the right main gear was also calculated which takes into account the runway slope and Euler angle rates; however the slope of the runway was unknown and therefore was not included in the closure rate calculation. At touchdown, the Euler angle rates were negligible (not shown) which resulted in a right main gear closure rate that was very similar to the descent rate at the CG of 3.0 fps (Figure 3).

Following the initial main gear ground contact, the speedbrakes deployed at about time 3862 seconds and approximately 1 second later the throttle levers began to transition to the reverse idle detent (Figure 3). At time 3865 seconds, large spikes in all three acceleration parameters were observed (Figures 3 and 4). These large spikes corresponded with the initiation of a bank angle change from 1 degree to 6 degrees to the right, the main gear discrete momentary transition to AIR for 1 second, and the nose gear discrete transition to GROUND for 1 data point. As the bank angle increased to the right, a left control wheel input was commanded to 35 degrees (Figure 4). A second set of smaller spikes in the acceleration data occurred just after time 3866 seconds as the bank angle reached 6 degrees and nose gear discrete transitioned to AIR [Figures 3 and 4]. The airplane came to rest at approximately time 3906 seconds while closely maintaining the runway heading (not shown).

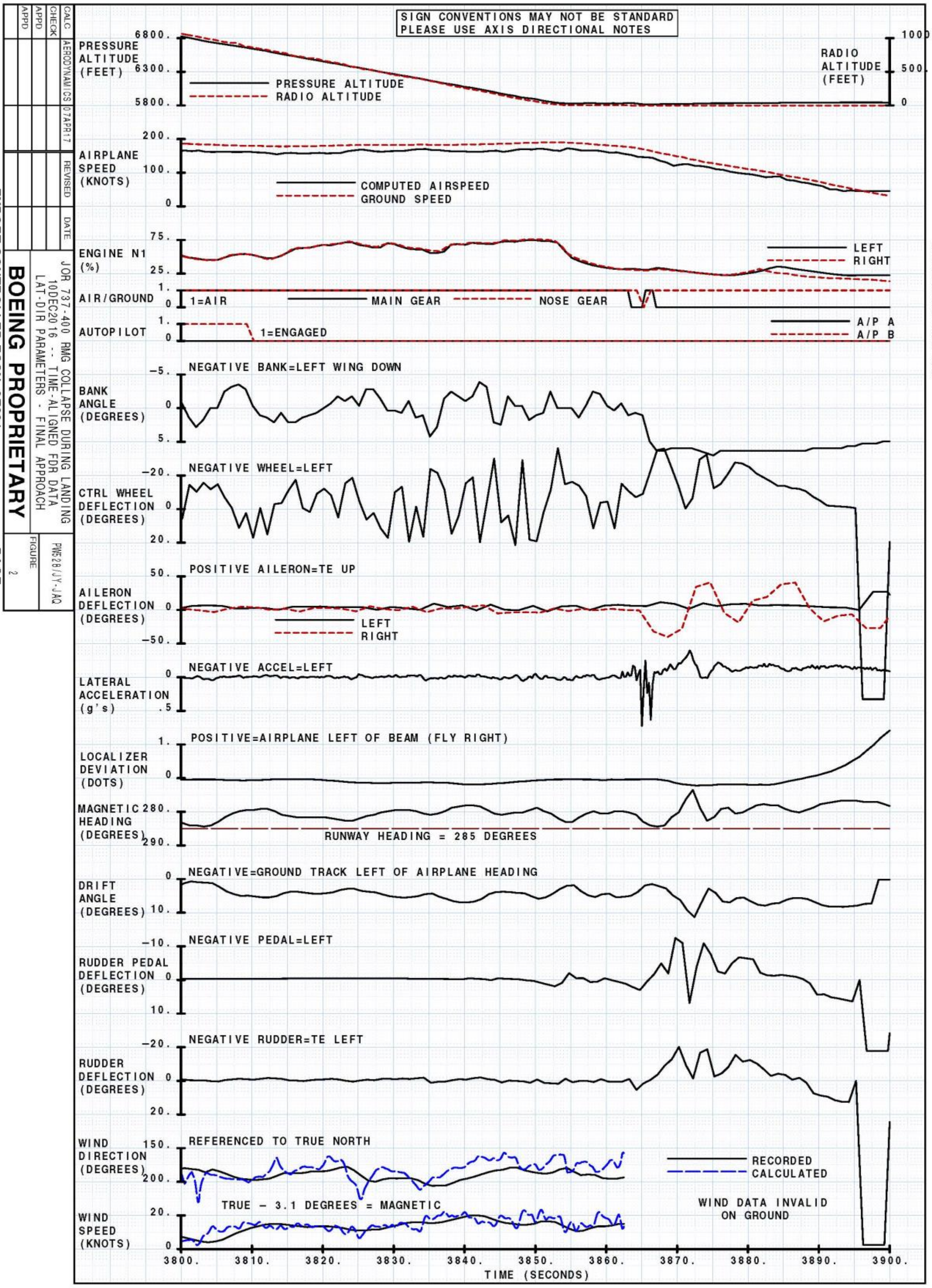
Between the initial main gear ground contact and the air/ground discrete transition to GROUND, the normal load factor, longitudinal acceleration, and lateral acceleration began to fluctuate until approximately time 3865 seconds when the large spikes in the accelerations were observed (Figures 3 and 4). In addition, the fluctuations in the lateral acceleration increased in magnitude during this time (Figure 4). Due to the report in the SR that the right main gear departed the airplane during the landing rollout, it was deduced that the first set of large acceleration spikes most likely corresponded to the loss of the right main gear. This is also the time that the bank angle began to increase to the right. The second set of acceleration spikes most likely corresponded to the airplane settling onto the right engine nacelle after banking to the right as a result of the loss of the right main gear. The airplane completed the landing rollout balanced on the left main gear and the right nacelle with a pitch attitude of approximately 2 to 3.6 degrees nose-up and bank angle of approximately 6 degrees to the right (Figures 3 and 4). Additional damage to the right wing control surfaces can been observed in the right aileron deflection. The deflection limits of the ailerons is +/-20 degrees. After the right main gear collapse at time 3865 seconds, the right aileron deflection increased to +/-40 degrees, whereas the left aileron deflection remained in the expected range (Figure 4).

A ground track was generated to show the airplane's path during the approach and landing rollout (Figure 5). Runway 29 at KBL has a length of 11,520 feet and a width of 140 feet. Longitudinal and lateral distances were calculated using a combination of inertial data (ground speed, drift angle, heading), glideslope/localizer deviation, and airport information (runway dimensions, taxiway dimensions, etc.). The airplane's actual final resting position was not provided. The distances shown in Figure 5 were calculated based on the analysis of the recorded FDR data without reference to a physical anchor position. If the final resting position is provided (latitude/longitude or runway distances), the calculated ground track can be adjusted. The calculated airplane path is referenced to the airplane CG.

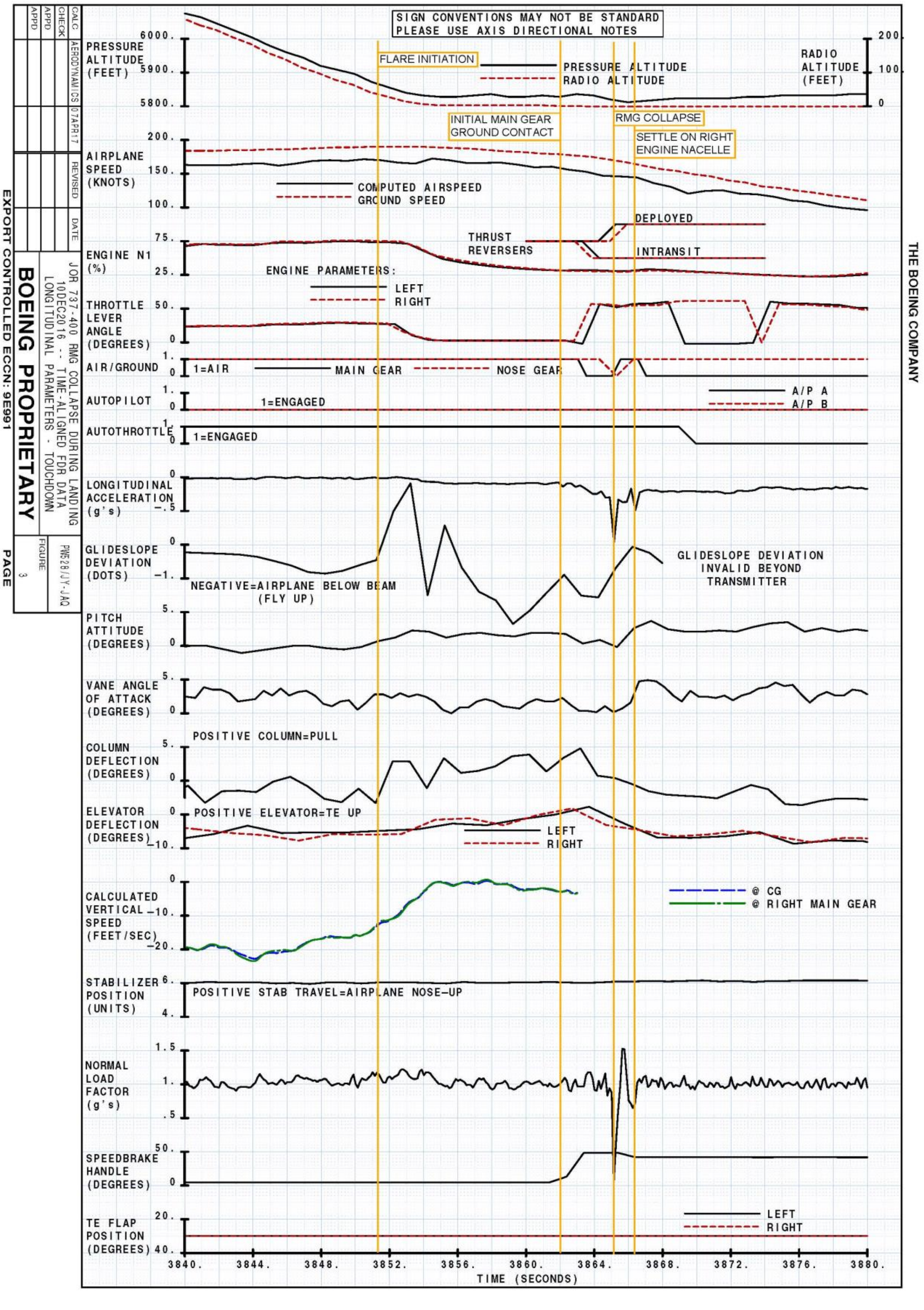
The ground track analysis results indicate that the airplane crossed over the runway threshold at 40 feet radio altitude and flare was initiated immediately after. Initial main gear contact occurred 3500 feet beyond the threshold as evidenced by the decrease in longitudinal acceleration and the speedbrake handle deployed soon after. The main gear air/ground discrete transitioned to GROUND at 3750 feet beyond the threshold. Large spikes in all three acceleration parameters occurred at 4350 feet beyond the threshold, which most likely correlates with the loss of the right main gear, followed by the bank angle increasing to the right with control wheel commanded to the left. The main gear discrete temporarily transitioned to AIR after the first set of acceleration spikes and the nose gear discrete transitioned to GROUND for 1 data point. At 4700 feet beyond the threshold, a second set of spikes was observed in the acceleration parameters just as the bank angle neared its maximum value of 6 degrees to the right, which most likely correlates to the airplane settling onto the right engine nacelle. At this point, the nose gear discrete transitioned back to AIR and the main gear discrete transitioned back to GROUND. The remainder of the landing rollout was performed on the left main gear and right engine nacelle, with the airplane pitch attitude between 2 and 3.6 degrees nose-up and the bank angle at approximately 6 degrees to the right. The estimated final stopping location of the airplane was 10,450 feet beyond the runway threshold and 20 feet to the left of the runway centerline.



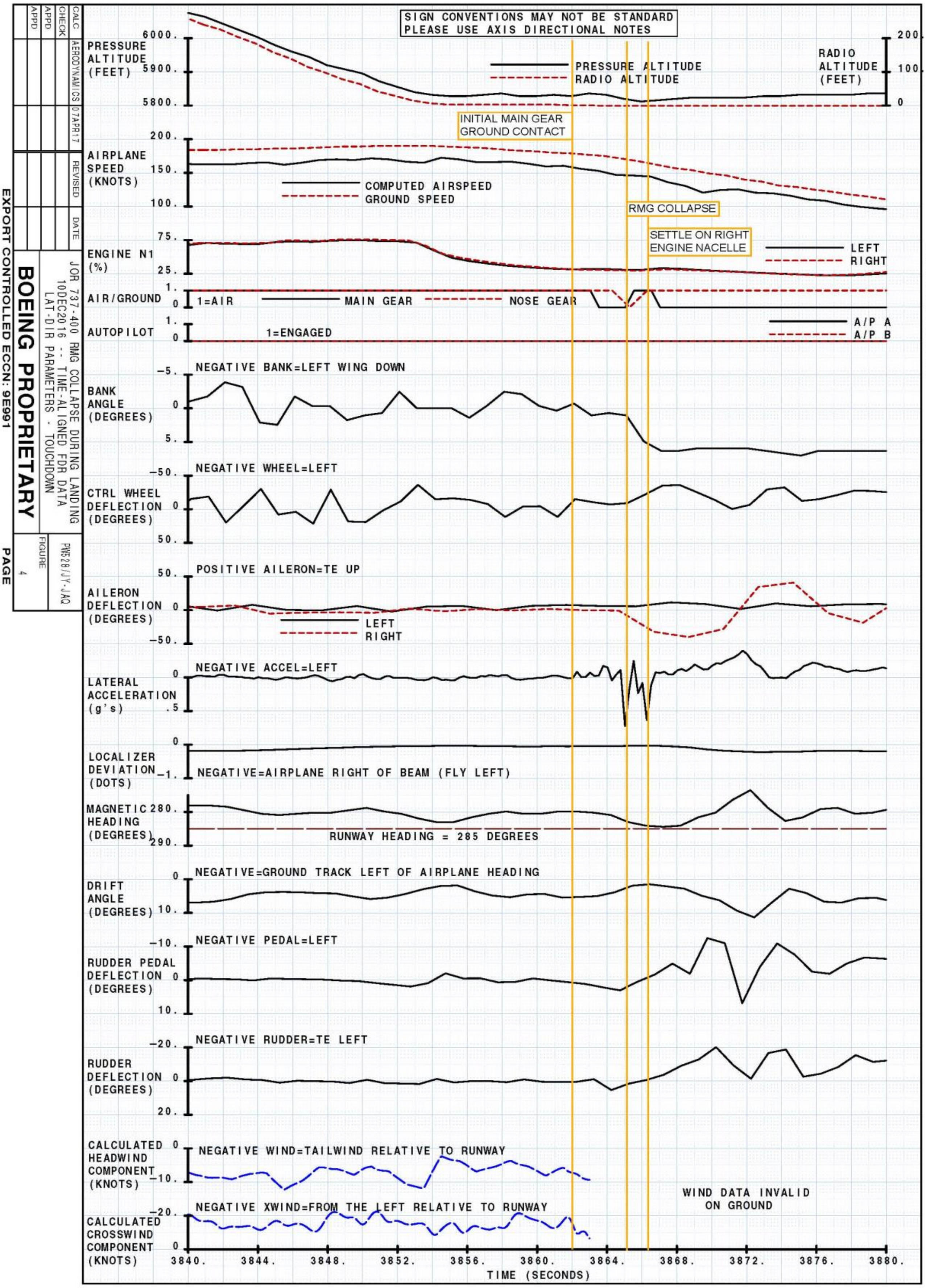
FDR Analysis – Figure1



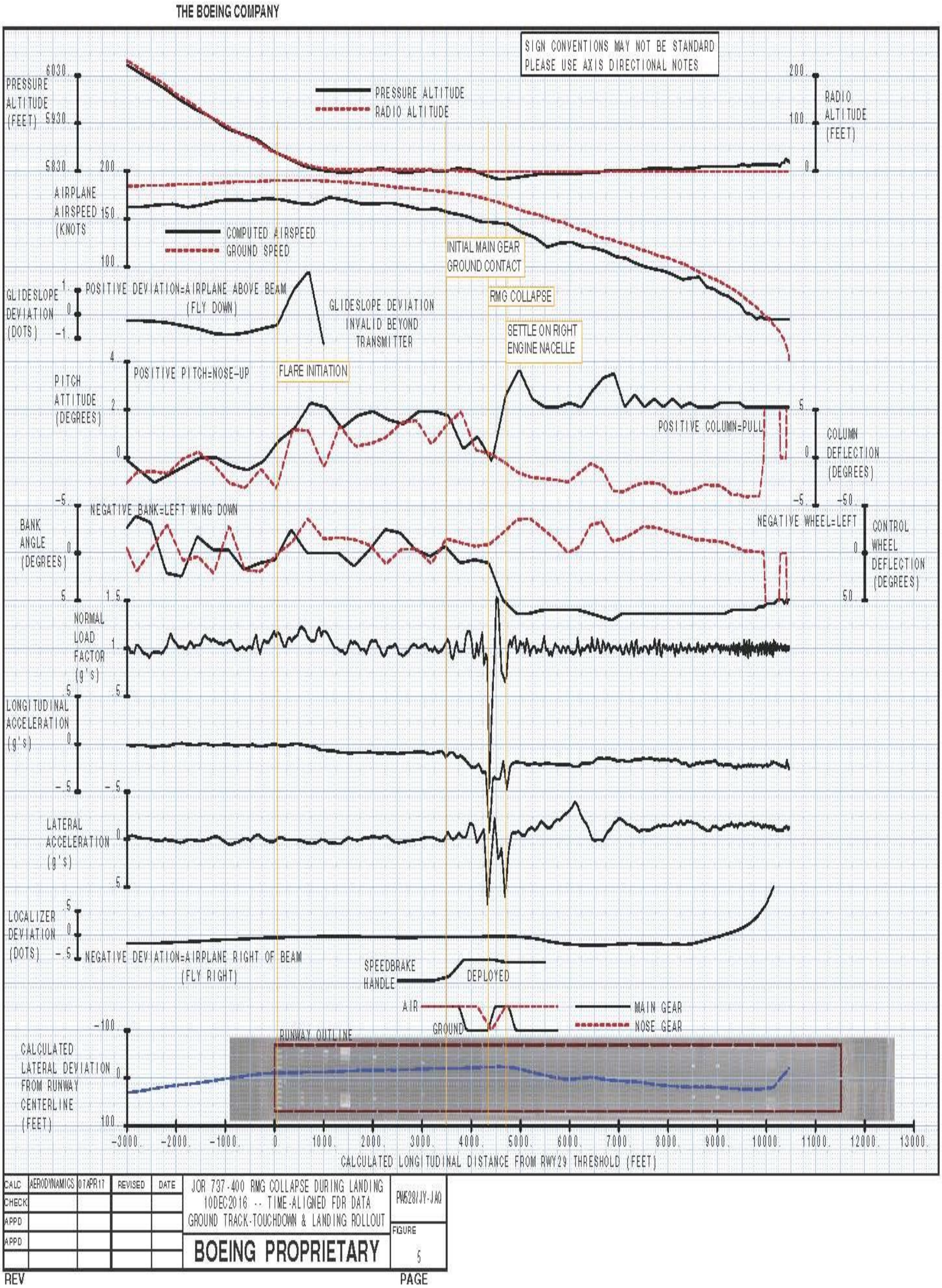
FDR Analysis - Figure 2



FDR Analysis - Figure 3



FDR Analysis - Figure 4



FDR Analysis - Figure 5

2.2. FLIGHT ANALYSIS

- The Flight from OAHR (Herat) – OHKB (Kabul) as a return flight, and Duty Started at 03:20 UTC in Kabul according to JAV Flight Records.
- OAKB - OAHR is a One Hour Twenty Minutes (1:20) flight Time as per the flight Plan.
- OAHR - OAKB is a One Hour Eight Minutes (1:08) flight Time as per the flight Plan and **155** Passenger and **09** Crew members,

FLIGHT PLANNING:

DOW	**35613 KG**	**PYLD/** **APYLD**	**14387 KG** **14754 KG**
EZFW	**50000 KG**	**MZFW** **AZFW**	**53000 KG** **50367 KG**
ETOW	**56920 KG**	**MTOW** **ATOW**	**68000 KG** **58467 KG**
ELDW	**53902 KG**	**MLDW** **ALDW**	**56200 KG** **55167 KG**

Findings

1. The flight was a return to base (Base of Operation) and a actual flight time of 1:08 minutes, The actual flight plan fuel planning:

   - Trip Fuel **: 3300 KG.**
   - T/O Fuel **: 8100 KG.**
   - Fuel Used **: 3100 KG.**
   - Fuel Remaining on Landing**: 5200 KG**

2. Load sheet Information:

   - MTOW : **60 000 KG**.
   - ATOW : **58 467 KG**. with under weight of 1533 KG.

3. This extra fuel load resulted in a higher final approach VREF and Touch Down Speeds.
4. ATC reported landing wind (CVR) on R/W 29 wind 190/15 KTS on landing clearance will result in a tail wind component of 1 KTS tail wind and 15 KTS Cross wind.
5. Jeppessen Chart ILS R/W 29 indicate a 3.50 Degrees angle which will result on a higher sink rate than normal approaches on different R/Ws.
6. All the above mentioned factors will result in higher ground speed and can effect in unstabilized approach which clearly indicated by (SINK RATE) EGPWS warning triggered bellow 300 Feet AGL and the commander gave the call to continue the landing and the F/O PF corrected for the sink rate and continued the landing resulting in floating for approximately 4 seconds and touchdown longer than normal landing.
7. Jordan Aviation is exercising different operations on wet lease bases on behalf of foreign operators and sometimes it operates to airports that requires specific crew and pilot training as they may have unusual and often difficult approaches . Jordan aviation have no evidence that Kabul airport has been categorized or a training for the crew in SAFI operation has been made for this airport. Jordan Aviation operation supervision need to create qualification requirement for certain route and airports were scheduling should account for level of experience requirements for certain flights and airports and should specify PIC

landings in certain runways and conditions, like the situation in hand (High Elevation, Higher than normal glide slope angle, Tail wind Close to the limit) situation indicate a PIC landing is more likely.

8. When Asked about the high fuel weight (5200 KG Fuel onboard) the PIC replied that Kabul is famous for drastic weather change and his alternate was the departure airfield.

9. Flight Duty and Rest Limitation was not considered a factor contributing to this occurrence.

10. Crew Qualification and Standard Operations Procedures (SOP).

   a. Jordan Aviation need to qualify and address steep approaches operation in their Operations Manuals and accommodate the required training in JAV Training Policy.

   b. Training was done on time and no reported deficiencies. But the training does not accommodate for the irregularity of operations and does include unstable approach recognition.

2.3 FLYING A STABILIZED APPROACH DISCUSSION

The following statements were extracted from the B737 CL Flight Crew Training Manual (FCTM) with regard to the Flight Safety Foundation's published criteria for flying a stabilized approach. It recommends that a go-around should be initiated if the approach becomes unstabilized under 1000 feet above the ground for instrument meteorological conditions and under 500 feet for visual meteorological conditions.

Stabilized Approach Recommendations

Maintaining a stable speed, descent rate, and vertical/lateral flight path in landing configuration is commonly referred to as the stabilized approach concept.

Any significant deviation from planned flight path, airspeed, or descent rate should be announced. The decision to execute a go-around is not an indication of poor performance.

Note: Do not attempt to land from an unstable approach.

The following recommendations are consistent with criteria developed by the Flight Safety Foundation.

All approaches should be stabilized by 1,000 feet AFE in instrument meteorological conditions (IMC) and by 500 feet AFE in visual meteorological conditions (VMC). An approach is considered when all of the following criteria are met:

- The airplane is on the correct flight path
- Only small changes in heading and pitch are required to maintain the correct flight path
- The airplane should be at approach speed. Deviations of +10 knots to – 5 knots are acceptable if the airspeed is trending toward approach speed
- The airplane is in the correct landing configuration
- sink rate is no greater than 1,000 fpm; if an approach requires a sink rate greater than 1,000 fpm, a special briefing should be conducted
- Thrust setting is appropriate for the airplane configuration
- All briefings and checklists have been conducted.

Specific types of approaches are stabilized if they also fulfill the following:

- ILS and GLS approaches should be flown within one dot of the glide slope and localizer, or within the expanded localizer scale
- Approaches using IAN should be flown within one dot of the glide path and FAC
- During a circling approach, wings should be level on final when the airplane reaches 300 feet AFE.

Unique approach procedures or abnormal conditions requiring a deviation from the above elements of a stabilized approach require a special briefing.

Note: An approach that becomes unstabilized below 1,000 feet AFE in IMC or below 500 feet AFE in VMC requires an immediate go-around.

These conditions should be maintained throughout the rest of the approach for it to be considered a stabilized approach. If the above criteria cannot be established and maintained until approaching the flare, initiate a go-around.

At 100 feet HAT for all visual approaches, the airplane should be positioned so the flight deck is within, and tracking to remain within, the lateral confines of the runway edges extended.

As the airplane crosses the runway threshold it should be:

- stabilized on approach airspeed to within +10 knots until arresting descent rate at flare
- On a stabilized flight path using normal maneuvering
- positioned to make a normal landing in the touchdown zone (the first 3,000 feet or first third of the runway, whichever is less).

Initiate a go-around if the above criteria cannot be maintained.

Maneuvering (including runway changes and circling)

When maneuvering below 500 feet, be cautious of the following:

- Descent rate change to acquire glide path
- Lateral displacement from the runway centerline
- Tailwind or crosswind components
- Runway length available.

2.4. FINDINGS ON SFW 502 FLIGHT APPROACH

Below 1000 feet radio altitude, the flight crew did not adhere to two of the above recommended stabilized approach criteria. These criteria are summarized below:

- Sink rate is no greater than 1000 fpm. Throughout the approach, there were several sink rate exceedance of 1000 fpm.

The CVR data show that a “Sink Rate” warning was triggered for 2 seconds between 159 - 115ft AAL. The average Vertical speed during the warning was -1093 ft/min.

This rate of descent warnings is normal on approach to a high altitude airport with a steep (3.5 degree glideslope) due to the higher True Airspeed and consequent higher Groundspeed. The rate of descent required to maintain a 3.5 degree glideslope with a Groundspeed of 180Kts is 1064ft/min.

- **The flight crew selected an approach speed of Vapp+10, while the ATC a wind of 140/07 which indicates a tailwind component of 6 knots, the crew should select Vapp+5 at that stage.**

Although they were selecting Vapp+10, the FDR data was showing an average of 165-170 knots IAS which is 15 – 18 knots higher than the selected approach speed, and that speed deviation continued until the aircraft reached the flare height were the trends went down towards a speed of Vapp+5.

2.5. FLARE TECHNIQUES DISCUSSION

The Flight Crew Training Manual also contains the following recommendations that are applicable to this event:

Initiate the flare when the main gear is approximately 20 feet above the runway by increasing pitch attitude approximately 2° - 3°. This slows the rate of descent.

After the flare is initiated, smoothly retard the thrust levers to idle, and make small pitch attitude adjustments to maintain the desired descent rate to the runway. A smooth thrust reduction to idle also assists in controlling the natural nose-down pitch change associated with thrust reduction. Hold sufficient back pressure on the control column to keep the pitch attitude constant. Ideally, main gear touchdown should occur simultaneously with thrust levers reaching idle.

Do not allow the airplane to float or attempt to hold it off. Fly the airplane onto the runway at the desired touchdown point and at the desired airspeed.

Prolonged flare increases airplane pitch attitude 2° to 3°. When prolonged flare is coupled with a misjudged height above the runway, a tail strike is possible. Do not prolong the flare in an attempt to achieve a perfectly smooth touchdown. A smooth touchdown is not the criterion for a safe landing.

The flare followed with aircraft floating action above the runway for a distance of 1,067 m from runway threshold was only justified with pilots' judgment to bleed the energy of the aircraft before touchdown to avoid a hard landing. The flight crew stated that this kind of techniques is always used in high altitude airports to avoid high energy touchdown keeping into account the remaining runway distance to stop the aircraft on the landing run.

2.6. SHIMMY EVENT DISCUSSION

The characteristics of the landing are consistent with past landing gear shimmy events. The airplane touched down at a high ground speed and low sink rate, and the air/ground discrete transition to GROUND occurred approximately 1 to 1.5 seconds after initial main gear ground contact, indicating that the struts were extended for that period of time. As a result, the torsion links of the shimmy damper remained in an extended, vertical position, where the damper has less mechanical advantage for longer periods of time. Despite the presence of shimmy damper hardware, which is designed to reduce the torsional vibration energy generated during landing, airplanes occasionally experience main landing gear shimmy. As a result, the torsion links of the shimmy damper remained in an extended, vertical position, where the damper has less mechanical advantage for longer periods of time.

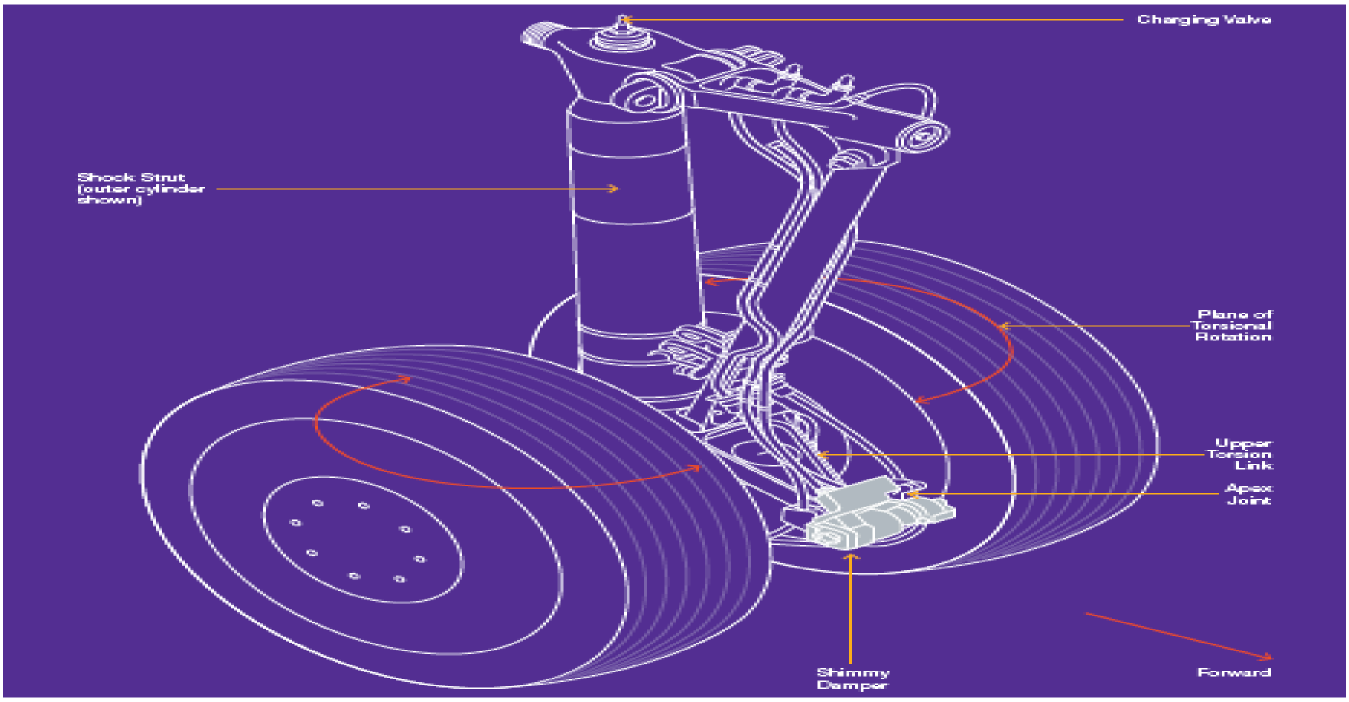
This information is extracted from AERO QTR_03, 13 The Boeing Edge magazine which conclude that;

“Based on operator reports, MLG shimmy is an infrequent event that is characterized by strong vibration, usually from one MLG, that begins at touchdown and continues until the airplane is fully stopped. Historically, there have been two or three shimmy events a year in the worldwide 737-200/ -300/-400/-500 fleet. However, in the last few years, the rate of shimmy events has increased sharply on these models. In a few particularly severe shimmy events, the affected main landing gear collapsed during the landing. This article discusses causes of shimmy and recommended actions operators can take to reduce the likelihood of it occurring. Boeing sometimes receives reports from operators of what is assumed to be a hard landing because of the violent nature of the landing and the observation of a torsion link fracture.

However, Boeing’s experience with these landings reveals that such damage actually suggests a shimmy event occurred. Despite the presence of shimmy damper hardware, which is attached to the apex lugs on each MLG and is designed to reduce the torsional vibration energy generated during landing, airplanes occasionally experience MLG shimmy. Shimmy events almost always result in damaged torsion links and shimmy dampers. When a torsion link is completely severed, it can leave oscillating tire marks on the runway. Following a shimmy event, the airplane typically needs to be temporarily removed from revenue-generating service for inspections and repairs. The Aero Magazine article concludes with the following “a shimmy event, the airplane typically needs to be temporarily removed from revenue-generating service for inspections and repairs”:

Due to the geometry of the torsion links, the shimmy damper is most effective when the landing gear strut is compressed in the ground mode. Lower touchdown descent rates increase the likelihood of a shimmy damper failure. It is important to note, however, that proper maintenance of the gear components is the best way to prevent shimmy damper failures. The possibility of landing gear shimmy events is greater at high altitude airports.

For shimmy to occur, the landing gear must have a force applied to it that excites this torsional vibration mode. The 737 has a vibration frequency of approximately 15 Hertz (Hz). Boeing engineers theorize that the force needed to initiate shimmy is probably an alternating drag force, such as if one tire touches down, causing a twisting motion of the inner cylinder in one direction and the second tire touches down a fraction of a second later, causing the inner cylinder to twist in the opposite direction. If the timing between the first tire and second tire contacting the runway is similar to the shimmy frequency, the gear can oscillate in the shimmy mode.



Boeing also recommends that pilots strive for a landing with normal sink rates with particular emphasis on ensuring that the auto speedbrakes are armed and deploy promptly at touchdown. An overly soft landing, or a landing in which the speedbrakes do not promptly deploy, allows the landing gears to remain in the air mode longer, which makes them more vulnerable to shimmy. This is especially true when landing at airports located at higher elevations, where the touchdown speed is increased.

Boeing has stated that a high-speed soft landing can contribute to excessive main gear shimmy or vibration in the 737-400 airplanes. This is detailed in Flight Operations Tech Bulletin (FTOB) 737-15 released December 14, 2015 which states “Based on analysis of main gear shimmy events, low sink rate landings of less than 1 ft/sec (60 feet/minute) can increase the possibility of inducing main gear shimmy”.

However, as indicated by a number of similar failures that have occurred on Boeing 737-400 aircraft around the world, there is clearly a design fault with the gear in combination with this aircraft:

The conditions at actual touchdown and whether the gear can handle these conditions are questionable. Boeing agrees that a high-speed soft landing can cause the excessive shimmy with resultant failure. But, nowhere does Boeing state what the actual limitations are in terms of the limiting groundspeed and or touch-down vertical forces which are usually measured in g. This aircraft did a flap 30 landing, while Boeing allows flap 15 landings and even flapless landings, which will result in much higher landing speeds than were recorded in this case, but nowhere in the Operations Manuals does Boeing state that pilots need to beware of shimmy conditions at high speed and with soft landings and that this can cause a failure of the gear. This was explained by Boeing as they do not provide limitations to pilots on this circumstances since maintenance, tire wear, runway conditions landing speed and firmness of landing can all contribute to some varying degree. Additionally; Boeing do not as a normal course of action provide consequences in the Operations Manual.

For SAW 502 Flight; a steep approach requirements for Kabul airport which has a 3.5 degrees glide slope profile and the high approach speed, while landing at a high altitude airport, resulted in excessive ground speed (165 - 170 knots) before touchdown. An extended flare that was the result of pilot judgment to bleed the aircraft energy to avoid a hard landing led to touchdown at a low sink rate (58 feet/minute).

2.7. ROOT CAUSES DETERMINED BY BOEING THAT MIGHT RENDER THE SHIMMY DAMPERS INEFFECTIVE

Although shimmy dampers have been very successful at preventing shimmy, problems can arise that render the dampers ineffective. Detailed studies of 737-200/-300/-400/-500 **shimmy events have revealed several root causes. In approximate order of likelihood, they are:**

- Excessive wear or freeplay in the joint where the shimmy damper connects to the lower torsion link (referred to as the apex joint). Wear at this location allows undamped torsional freeplay to exist in the landing gear at the apex joint, which greatly increases the likelihood of shimmy.

- Wear or freeplay in the torsion link bushings (e.g., where the torsion links connect to the outer and inner cylinder). Wear at these locations also allows undamped torsional freeplay.

- Landing with extremely low sink rates. This type of landing is more likely to experience shimmy than a firmer landing because the torsion links remain in an extended, vertical position where the damper has less mechanical advantage for longer periods to time.

- Air in the damper. Several shimmy events occurred within a few flights after a new or overhauled damper was installed. In these cases, it is suspected that a thorough bleeding of air from the damper was not performed, thus preventing proper damper operation.

- Damper piston fracture. In a small number of events, it is suspected that the damper piston fractured due to a preexisting fault (e.g., a fatigue crack).

- Overserviced shock strut. In several events, an overserviced shock strut has been suspected to have been a contributing factor. A shock strut overserviced with nitrogen allows the torsion links to have a reduced mechanical advantage to react to the torsional motion of the inner cylinder.

- Incorrect damper installation. In one event, a damper designed for a very early 737-200 had inadvertently been installed on a later airplane that required a more heavy-duty damper.

- Unconnected hydraulic tube. In one event, a hydraulic tube for the damper was inadvertently left unconnected after unrelated maintenance, so there was no hydraulic fluid available to the damper.

2.8. MAINTENANCE RECORDS

Part I

Aircraft Information

Manufacturer	Boeing Commercial Airplane Company
Type	B737-400
Registration	JY-JAQ
Aircraft Serial Number	27826
Year of manufacture	08/02/1995
Power plant (Engines)	Two CFM56 3C turbofan engines
Configuration	Passenger 170 Y/C
Total airframe hours	56805:13 at 10 December 2016
Total airframe cycles	28,611 at 10 December 2016
Last Weighing Report	22/10/2015
Center of Gravity	14.17%
Certificate of Registration	No. 544 date of Initial Issue 21/12/2010. Date of Re Issue 23/04/2015
Certificate of Airworthiness	First issue 21/12/2010. Renewed 21/12/2014. Expiry 20/12/2016
Airworthiness Review Certificate	Renewed 21/12/2015. Expiry 20/12/2016

Engines information

Engines type	Position	Date of Installation	S/N	LSV Date	TSN	CSN	CSO	TSO
CFM56-3C	#1	09/10/2016	724637	29/09/2016	56223	39758	240	301
CFM56-3C	#2	09/10/2016	857806	08/10/2016	46995	24307	240	301

Auxiliary Power Unit (APU) information

APU type	S/N	LSV Date	TSN	CSN	CSO	TSO
GTCP85-129H	P-100004	29/08/2008	40789:04	UNK	2523	2679:22

Landing gears information

Position	P/N	S/N	Last OVH Date	Next OVH Date	Last Shop Visit for Repair	Remaining Days
NLG	65-73762-21	CPT2772ET	29/09/2009	29/09/2019	07/02/2013	1021
LH MLG	65-73761-121	MCO4803P2420	8/06/2007	08/06/2017	30/10/2013	179
RH MLG	65-73761-122	MCO4804P2420	12/06/2007	12/06/2017	29/10/2013	183

Position	Current CSN	Total Cycles @OVH	Next Total Cycles For OVH	Remaining Cycles
NLG	40537	34598	55598	15061
LH MLG	34114	23322	44322	10208
RH MLG	34114	23322	44322	10208

Aircraft Maintenance History

The last “A” check performed on the aircraft was the “3A” on 27/11/2016 at Kabul (KBL).
The last “C” check performed on the aircraft was the “3C” on 04/11/2014 at AMM (Amman).
The below shows the no. 3 and no. 4 tire/wheel assembly and brake changes (parts affected by the accident) during the whole year of 2016:

Tire/wheel assembly /brake	Date	Position	P/N off	S/N off	P/N on	S/N on
Tire/wheel assembly	14/01/2016	No. 3	3-1484	0194	3-1484	0647
Tire/wheel assembly	02/03/2016	No. 3	3-1484	0647	3-1484	0305
Tire/wheel assembly	04/06/2016	No. 3	3-1484	0305	3-1484	0227
Tire/wheel assembly	18/07/2016	No. 3	3-1484	0227	3-1484	0713
Tire/wheel assembly	20/08/2016	No. 3	3-1484	0713	3-1484	0227
Tire/wheel assembly	25/09/2016	No. 3	3-1484	0227	3-1484	0091
Tire/wheel assembly	17/11/2016	No. 3	3-1484	0091	3-1484	0317
Tire/wheel assembly	11/01/2016	No. 4	3-1484	0913	3-1484	0225
Tire/wheel assembly	25/02/2016	No. 4	3-1484	0225	3-1484	0963
Tire/wheel assembly	15/05/2016	No. 4	3-1484	0963	3-1484	0647
Tire/wheel assembly	23/06/2016	No. 4	3-1484	0647	3-1484	0193
Tire/wheel assembly	15/09/2016	No. 4	3-1484	0193	3-1484	0355
Tire/wheel assembly	04/11/2016	No. 4	3-1484	0355	3-1484	0149
Brake assembly	08/02/2016	No. 3	2-1474-7	0322	2-1474-7	5618
Brake assembly	09/07/2016	No. 3	2-1474-7	5618	2-1474-7	2319

JY-JAQ Started operation in Afghanistan on 9/10/2016, the last flight was on 10/12/2016 with 241 FC and 301:40 FH during this period. The followings are the last scheduled maintenance checks performed during the operation:

- Preflight check; latest one done on 10/12/2016, at Herat (HEA), technical log sheet no. 20568, with no defects reported.
- Daily check; latest one done on 10/12/2016, at Kabul (KBL), technical log sheet no. 20566, with no defects reported.
- Weekly check; latest one done on 04/12/2016 at Dubai (DXP), technical log sheet no. 17883, with no defects reported.
- 3A check dated 27/11/2016 at Kabul (KBL) – Certificate of Release to Service no. 081/2016, next due for the subject check is at 56978 FH.

The aircraft had 16 open deferred defects at the time of the occurrence, nothing related to the landing gear.

It was noted that a suspected hard landing was reported on 13/11/2016 at Kabul (KBL) and the aircraft was inspected I.A.W AMM 05-51-51showing no damage on the aircraft, technical log sheet no. 22318.

It was noted that all landing gear shock struts were serviced I.A.W AMM 12-15-31 and AMM 12-15-41 with dry nitrogen on 30/06/2016, based on an open defect as per inspection discrepancy sheet no. 7151, the latter corrective action was followed up on the deferred defect sheet no. 3038 dated 30/06/2016, in order to check the X-dimension of all landing gear shock struts after 5 to ten landings, and this deferred defect was closed by the satisfactory check of the X-dimension of all landing gear shock struts with no further defects on 06/07/2016.

Part II

Boeing Maintenance Planning Document (MPD) no. D6-38278 calls for the following inspections regarding the shock strut:

a. Every **7days** to clean exposed surface of the LH and RH and nose landing gear strut piston with a cloth moistened with MIL-H-5606 hydraulic fluid and wipe with dry cloth and to check the X-dimension extension on strut piston to verify that piston is not flat.
b. Every **2A** to visually check the LH and RH landing gear shock/side/drag struts, doors, torque links, gear actuators and associated hardware for condition and security of installation.
c. Every **1C** to service the LH and RH MLG shock strut **and** to functionally check LH and RH Main Landing Gear (MLG) torsion link freeplay at the apex/shimmy damper

The above mentioned inspections were included in the approved Jordan Aviation Maintenance Program, and were checked for implementation as per the below:

a. The 7day inspection at Kabul was performed 8 times as per the approved weekly check form no. JAV/CAMO/070 with no further defects,
b. The last two 2A checks, during August and October 2016, were checked specifically for the maintenance tasks related to the shock struts, and the records were satisfactory.
c. The last two 1C checks, during April/2012 and Oct/2014, were checked specifically for the maintenance tasks in item (c) above, and the records were found satisfactory with the following remarks:
    1. Subtask no. 32-11-00-846-052 from task card no. 32-011-03-02 for the RH MLG torsion links apex joint inspection, during the 1C check of Oct/2014 was not signed, though the subtask after it 32-11-00-820-003 was signed which calls for performing the same subtask 32-11-00-846-052 again.
    2. A follow up on subtask no. 12-15-31-213-013 which calls for *“examining the shock strut pressure and X dimension and if necessary to inflate it, and to service the shock strut with air and nitrogen, five to ten in-service landings after a complete oil and nitrogen servicing”* from task cards no. 15-015-31-01/02 related to the LH and RH gear strut servicing, during the 1C check of Oct/2014 had no evidence of being examined and serviced.

3. CONCLUSIONS

3.1 FINDINGS

3.1.1. The pilots held valid licenses and medical certificates.

3.1.2. The aircraft had a valid Certificate of Airworthiness (C of A) and Certificate of Registration (C of R) and was operated within the weight and balance envelop.

3.1.3 There were no reports of aircraft system abnormalities during flight.

3.1.4. The torsion link and shimmy damper of the right Main Landing Gear (MLG) assembly found broken.

3.1.5. Oscillating tire marks left on the runway.

3.1.6. The aircraft gross landing weight was 123.100 pounds LB, (the maximum design landing weight is 123.899 LB).

3.1.7. Based on the Landing weight and flap position , the landing reference speed (VREF) should have been approximately 142 knots.

3.1.8. During the approach the airplane experienced an average of 7-knots tailwind with an approximate 15-knots left crosswind component.

3.1.9. The main Landing Gear (MLG) contacted the runway at a computed airspeed of approximately 158 knots (VREF+16) and ground speed 178 knots.

3.1.10. The speedbrake deployed immediately after the airplane touched down at 3500 feet beyond the threshold.

3.1.11. The airplane touched down at a high ground speed and low sink rate.

3.1.12. The lateral acceleration starts to fluctuate and grown until gear collapse.

3.1.13. A “Sink Rate” was triggered by EGPWS warning for 2 seconds between 159 - 115ft AAL. The average Vertical speed during the warning was -1093 ft/min.

3.1.14. The flight crew selected an approach speed of Vapp+10, while the ATC a wind of 190/15 which indicates a tailwind component of 1 knots, the crew should select Vapp+5 at that stage.

3.1.15. The PIC declared Emergency to the ATC and the cockpit crew initiated an evacuation command from the left side of the aircraft. Evacuation was successfully accomplished with No reported injuries.

3.1.16. Based on the maintenance records, all airworthiness requirements were fulfilled at the time of the accident

3.1.17. Extra fuel load resulted in a higher final approach VREF and Touch Down Speeds.

3.1.18. ATC reported landing wind (CVR) on R/W 29 wind 190/15 Knots on landing clearance will result in a tail wind component of 1 Knots tail wind and 15 Knots Cross wind.

3.1.19. Jeppessen Chart ILS R/W 29 indicate a 3.50 Degrees angle which will result on a higher sink rate than normal approaches on different R/Ws.

3.1.20. Nowhere in the Operations Manuals does Boeing state that pilots need to beware of shimmy conditions at high speed and with soft landings and that this can cause a failure of the gear.

3.1.21. Jordan Aviation Operation depend very much on lease out to foreign operators and sometimes to use strange airfields operation. Jordan aviation training policy does not account for Route and Airfield competency.

3.2 CAUSE(S)

The Investigation committee determines that the airplane occasionally experienced main landing gear shimmy and the most probable cause indicated that the struts were extended for long period of time. As a result, the torsion link of the shimmy damper remained in an extended vertical position, where the damper has less mechanical advantage for longer periods of time. Despite the presence of shimmy damper hardware which is designed to reduce the torsional vibration energy generated during landing.

3.3. CONTRIBUTING FACTORS

Contributing factors to the event include:

- High altitude airport of 5877 feet
- An overly soft landing, allows the landing gears to remain in the air mode longer, which makes them more vulnerable to shimmy
- Touchdown with a closure rate of 1 fps, which is considered overly soft and may increase the risk of shimmy torsional forces
- High ground speed at touchdown of 178 knots ,which resulted from the high touchdown airspeed of 158 knots , touchdown at (VREF+16)

4. RECOMMENDATIONS

The CARC has published the following Safety Recommendation in reference letter 31/100/508/15 on preventing MLG shimmy events to Jordanian operators that operate the Boeing B737-300/400/500 aircraft.

The Hashemite Kingdom Of Jordan
Civil Aviation Regulatory Commission

المملكة الأردنية الهاشمية
هيئة تنظيم الطيران المدني

Ref. : 31/100/508/15 الرقم :

Date : /04/2017 التاريخ :

Jordan Aviation
Fly Jordan

Subject: Safety Recommendation on Preventing Main Landing Gear (MLG) Shimmy Events

Reference : Boeing Article describes a MLG shimmy event and how they occur and how to prevent them.

Shimmy Description :

MLG shimmy is the rare event that starts at airplane touchdown and continues during rollout, Boeing has determined several causes of shimmy, particularly for the B737-200/-300/-400/-500 fleet and recommends specific actions that can prevent this vibration from occurring.

Recommended Operator Action (maintenance) :

Boeing has published the following maintenance documents that advise operators of recommended maintenance practices to prevent shimmy events:

a. Service Letter 737-SL-32-057.
b. Multi-Operator Message MOM-MOM-12-0127-01B.
c. Fleet Team Digest Article 737-FTD-32-11001.
d. 737 Aircraft Maintenance Manual 32-11-00/601, Torsional Free Play Inspection.
e. 737 Aircraft Maintenance Manual 32-11-81/501, Main Gear Damper Adjustment.

Boeing has revised the relevant aircraft maintenance manuals (AMMs) and component maintenance manuals (CMMs) to improve the directions and procedures concerning shimmy damper and torsion link maintenance.

You are kindly requested to fully adhere to the maintenance practices established in Boeing technical publications; this includes the inspections as required in the Aircraft Maintenance Manual as per the intervals listed in the approved maintenance program.

The Hashemite Kingdom Of Jordan
Civil Aviation Regulatory Commission

المملكة الأردنية الهاشمية
هيئة تنظيم الطيران المدني

Ref. : 31/100/508/15 الرقم :

Date : /04/2017 التاريخ :

Recommended Operator Action (Operational) :

Boeing also recommends that pilots strive for a landing with normal sink rates with particular emphasis on ensuring that the auto speedbrakes are armed and deploy promptly at touchdown. An overly soft landing, or a landing in which the speedbrakes do not promptly deploy, allows the landing gears to remain in the air mode longer, which makes them more vulnerable to shimmy. **This is especially true when landing at airports located at higher elevations, where the touchdown speed is increased.**

In addition, pilots are kindly requested to report any event of a main landing gear shimmy or vibration to aircraft during landing or takeoff.

In light of the above it is highly recommended to discuss the shimmy, the causes of shimmy and the operator actions stated in references (a),(b) and (c) above that can be taken to reduce the likelihood of shimmy with all concerned staff (pilots, engineers, etc).

Best Regards,

Capt. Haitham Misto
Chief Commissioner

cc: Director Flight Operations Standards.
Director Airworthiness Standards.

6.0 COMMENTS AND RESPONSES

6. 1 CARC RESPONSE ON THE BOEING COMMENTS

No	Section/Page/Line	Proposed Change	Rationale	Response
1	1.11 Flight Recorders/ page 18/ line 5	And lately the ~~row~~ raw data has been sent to the Boeing	Correct data description	accepted
2	1.11 Flight Recorders / page 18 / line 7	The point of touchdown of the Aircraft with the runway was approximately ~~1,160~~ 1067 meters from runway 29 threshold, approximately…	Our ground track analysis showed touchdown at 3500ft/1067m. Suggest changing the touchdown length	accepted
3	1.11 Flight Recorders / page 18 / line 10	Aircraft came to rest at ~~430~~ 326 meters from runway 11 threshold.	Our ground track analysis show the airplane came to rest 1070ft/326m from the end of the runway. Suggest changing the point of rest	accepted
4	2.5 Flare Techniques Discussion / page 32 / line 24	The flare followed with aircraft floating action above the runway for a distance of ~~1,160~~ 1067 m from runway…	Our ground track analysis showed touchdown at 3500ft/1067m. Suggest changing the touchdown length.	accepted
5	2.6 Shimmy Event Discussion / page 32 / line 32	~~The airplane touched down at a high ground speed and low sink / closure rate. The air / ground discrete transition to GROUND occurred approximately one second after touchdown, indicating that the struts were extended for the period of time starting from the flare at 40 ft and for 9 seconds at height(s) 3 – 1 ft above the runway.~~ The characteristics of the landing are consistent with past landing gear shimmy events. The airplane touched down at a high ground speed and low sink rate, and the air/ground discrete transition to GROUND occurred approximately 1 to 1.5 seconds	The flare is an irrelevant time reference for this event. The length of time that is critical is after the wheels have ground contact and when the strut compresses. It is during this time that torsion links are less effective while in the extended position. We suggest changing the description as above.	accepted

		after initial main gear ground contact, indicating that the struts were extended for that period of time. As a result, the torsion links of the shimmy damper remained in an extended, vertical position, where the damper has less mechanical advantage for longer periods of time. Despite the presence of shimmy damper hardware, which is designed to reduce the torsional vibration energy generated during landing, airplanes occasionally experience main landing gear shimmy.		
6	*2.6 Shimmy Event Discussion / page 33 / line 7*	*Following a shimmy event, the airplane typically needs to be temporarily removed from revenue-generating service for inspections and repairs."*	*Suggest adding the quotation marks to end the Aero magazine article quote.*	*accepted*
7	*2.6 Shimmy Event Discussion / page 33 / line 22*	*…ensuring that the auto speed brakes speedbrakes are armed and deploy promptly at touchdown. An overly soft landing, or a landing in which the ~~speed brakes~~ speedbrakes do not promptly deploy, allows …*	*Speedbrakes are one word. Suggest making the change as shown.*	*accepted*
8	*2.6 Shimmy Event Discussion / page 34 / line 1*	*~~As indicated by a number of similar failures that have occurred on Boeing 737-400 aircraft around the world, there is clearly a design fault with the gear in combination with this aircraft:~~* *~~The conditions at actual touchdown and whether the gear can handle these conditions are questionable. Boeing agrees that a high-speed soft landing can cause the excessive shimmy with resultant failure. However, nowhere does Boeing state what the actual limitations are in terms of the limiting groundspeed and or touch-down vertical forces which are usually measured in g. This aircraft did a flap 30 landing, while Boeing allows flap 15 landings and even flapless landings, which will result in much higher landing speeds than were recorded here, but nowhere in the Operations Manuals does Boeing state that pilots need to beware of shimmy conditions at high speed and with soft landings and that this can cause a failure of the gear.~~*	*Suggest revising this section as detailed above. Boeing has provided Flight Operations Tech Bulletin 737-15 to operators to inform pilots of the consequences of high speed soft landings. We do not provide limitations to pilots on this circumstance since maintenance, tire wear, runway conditions, landing speed and firmness of landing can all contribute to some varying degree. Also, we do not as a normal course of action provide consequences in the Operations Manuals.*	*Accepted for the second part added by Boeing, however, the first paragraph was not deleted*

		Boeing has stated that a high-speed soft landing can contribute to excessive main gear shimmy or vibration in the 737-400 airplane. This is detailed in Flight Operations Tech Bulletin (FTOB) 737-15 released December 14, 2015 which states "Based on analysis of main gear shimmy events, low sink rate landings of less than 1 ft/sec (60 feet/minute) can increase the possibility of inducing main gear shimmy". *For SAW 502 Flight; a steep approach requirements for Kabul airport which has a 3.5 degrees glide slope profile and the high approach speed, while landing at a high altitude airport, resulted in excessive ground speed (165 - 170 knots) before touchdown. An extended flare that was the result of pilot judgment to bleed the aircraft energy to avoid a hard landing led to touchdown at a low sink rate (58 feet/minute).*		
9	*3.3 Contributing Factors / page 40 / line 17*	~~*-Oscillations were visible in lateral acceleration, normal load factor, and*~~ ~~*-longitudinal acceleration starting around initial main gear ground contact. It is possible that, before the main gear air/ground discrete transitioned to GROUND,*~~ ~~*-high frequency oscillations*~~ *-Oscillations were visible in normal load as well as latitudinal and longitudinal accelerations starting around initial main gear ground contact. It is possible that, before the main gear air/ground discrete transitioned to GROUND, oscillations in the 15 Hertz frequency occurred (force needed to initiate a shimmy event).*	*If the intent of this contributing factor was to correlate the accelerations measured on the FDR with oscillations of the main gear, then Boeing recommends the above.*	*Accepted and the whole point was removed from the report as it does not contribute to the occurence*

6. 2 CARC RESPONSE ON JAV COMMENTS

No	*Section/Page/Line*	*Proposed Change*	*Rationale*	*Response*
1	XX / OBJECTIVE / 2	*This event ~~is being~~ has been investigated by the Jordan Aircraft Accident Investigation Department (AAID) with assistance from accredited representatives of the United States National Transportation Safety Board (NTSB) and Boeing. The flight data recorder (FDR) data were provided to Boeing for analysis.*	Grammar	*accepted*
2	XX / OBJECTIVE / 2	*~~During the course of this investigation any immediate safety concerns will be addressed by safety recommendation (s).~~*	the final report shall not address issues that refers to earlier reports (initial / preliminary report)	*accepted*
3	XX / ABBREVIATIONS / 3	*to add the following abbreviations:* *RFF > Rescue and Firefighting* *JORAMCO > Jordan Automotive Maintenance Limited (A Service Provider for JAV)* *TLS > Technical Log Sheet* *IAW > In Accordance With*	The recommended abbreviations came in the context of the report, so need to be added to abbreviations table	*accepted*
4	TABLE OF THE CONTENTS / 4	*To add sections 1.12, 1.13 and to correct 1.14 as necessary*	Consistency of report TOC	*accepted*
5	1.1 / HISTORY OF THE FLIGHT / 6	*The aircraft departed ~~Kabul~~ Herat with 164 passengers ….*	Fact	*accepted*
6	2.4 / FINDINGS ON SFW 502 FLIGHT APPROACH / 31	*The flight crew selected an approach speed of Vapp+10, while the ATC reported a surface wind of 190/15 ~~140/07~~ which indicates a tailwind component of 2 ~~6~~ knots, the crew should select Vapp+5 at that stage.*	reference to section 2.2 investigator wrote that the tower reported wind of 190/15 according to CVR This shall be consistent throughout the whole report as discrepancies were found in many places, for example: • In section 2.4 § five it was	*accepted*
7	3.1 / FINDINGS / 39	*The flight crew selected an approach speed of Vapp+10, while the ATC reported a surface wind of 190/15 ~~140/07~~ which indicates a tailwind component of 2 ~~6~~ knots, the crew should select Vapp+5 at that stage.*		

			indicated as 140/.7 In the Findings 3.1.14 it was noted as 140/07	
8	1.3 / DAMAGE TO AIRCRAFT / 7	*The Aircraft sustained a substantial damage as it can be seen from the pictures, the actual damages and status of the aircraft ~~will~~ is determined in the damage report, in addition to the pictures shown below the following estimation for the damage can be summarized with the following;*	Grammars	*accepted*
9	1.3 / DAMAGE TO AIRCRAFT / 7	*…… the aircraft was skidding on its Engine # 2 hence an additional damage to the underside of the right engine nacelle occurred as it was sliding along the surface during the landing roll. ~~Refer to damage report (Attached).~~*	No damage report is attached to the reviewed document	*accepted*
10	1.6.3.2 / MAIN GEAR DESCRIPTION AND OPERATION	*the aircraft was released ~~form~~ from "2A" check maintenance and Engines replacement as per Certificate Ref. #: 066/2016,*	Grammar	*accepted*
11	SUBHEADING IN PAGE 18 IS COVERED BY THE PHOTOS OF FDR/CVR	*This subheading shall reads* *1.12 WRECKAGE AND IMPACT INFORMATION*	Consistency and order of headings	*accepted*
12	2.2 / FLIGHT ANALYSIS / 29	*ATC reported landing wind (CVR) on R/W 29 wind 190/15 KTS on landing clearance will result in a tail wind component of ~~12.9~~ 6 KTS tail wind and ~~7.5~~ 15 KTS left Cross wind*	Wrong calculation for the surface wind components	*accepted*
13	2.2 / FLIGHT ANALYSIS / 29	~~*Jordan Aviation Operation depend very much on lease out to foreign operators and sometimes to use strange airfields operation. Jordan aviation training policy does not account for Route and Airfield competency*~~	The JORDAN AVIATION Flight Crew Training & Checking Programme as per Operations Manual Part D covers Route & Aerodrome Competence Qualification Volume 1, Chapter 2, Section 2.10	*Rejected*

			Date of Issue AUG 2016 Copies of the 6 pages attached	
14	2.2 / FLIGHT ANALYSIS / 30	~~*Jordan Aviation operation supervision need to create qualification requirement for certain route and airports were scheduling should account for level of experience requirements for certain flights and airports and should specify PIC landings in certain runways and conditions, like the situation in hand (High Elevation, Higher than normal glide slope angle, Tail wind Close to the limit) situation indicate a PIC landing is more likely.*~~ Whilst Jordan Aviation has a procedure for the selection of crews based on operational reviews of the areas of operation, producing risk assessments and managing the contents in Operations Manual Part C categorization, suggest that this needs to be developed further to ensure that the criteria is known in terms of airports or circumstances where PIC is required to be the PF	The crew operating this service had experience in respect of operating to/from Kabul	*rejected*
15	2.2 / FLIGHT ANALYSIS / 30	*Flight Duty and Rest Limitation ~~no none compliances~~.was not considered a factor contributing to this occurrence*	No None compliance does not provide a helpful meaning	*accepted*
16	2.2 / FLIGHT ANALYSIS / 30	~~Standard Operations are not clearly specified in OM-B concerning standard callouts, and procedures, instructions and limitations to carry out certain tasks like high Cross or tail wind, Runway water and ice contamination … etc.~~	According to JAV OM-B References: CHP 1 OPERATING LIMITATIONS points (h) and (k) wind limits including tail and cross winds are documented and demonstrated to pilots.in addition to wet and contaminated runway use CALLOUTS/ PROCEDURES and	*accepted*

			INSTRUCTIONS recommended by the manufacture of the aircraft (BOEING) are included in Chapter 2 (m) for Windshear abnormal situation. Boeing do not provide recommendations or material for Tailwind or cross wind callouts solely for the following reasons: wind reports are usually reported to the crew from different sources ATIS/ATC or Weather report and in this case there is No requirement for a call out and instead of that the pilots will plan for their approach and landing with the available information which is also monitored through the PROGRESS PAGE on the CDU Tailwind and Crosswind may result from abrupt change in wind velocity or direction and this is technically called Windshear. In this case the OM-B which is constructed In accordance with CARC guidance (OM-B structure checklist) only observes and requires the Windshear	

			callouts to be made and JAV OM-B satisfies this requirement as demonstrated in Windshear Escape Maneuver. For Runway and Ice Contamination: No CALLOUTS are required and the procedure is also available in both the OM-B CHAPTER 2 Amplified Procedures and QRH CHAPTER PI Tables and TEXT	
17	2.2 / FLIGHT ANALYSIS / 30	*b. Steep approaches. Jordan Aviation need to qualify and address steep approaches ~~and narrow runway operation~~ in their Operations Specification and accommodate the required training in JAV Training Policy.*	Narrow runway operation is irrelevant to this occurrence	*accepted*
18	2.2 / FLIGHT ANALYSIS / 30	*c. Training was done on time and no reported deficiencies. But the training does not accommodate for the irregularity of operations and does include unstable approach recognition ~~not encourage missed approach~~.*	JAV has made extensive efforts before and after the occurrence in encouraging go around whenever unstabilized approach is detected. This also evidenced by company procedures outlined in OM-A 8. Stabilized approach criteria in which the policy emphasize on the importance of go around following an unstabilized approach	*accepted*
19	3.0 / CONCLUSION / 39	*3.1.14. The flight crew selected an approach speed of Vapp+10, while the ATC a wind of 140/07 which indicates a tailwind component of 6 knots, the crew*	*3.1.14. The flight crew selected an approach speed of Vapp+10, while the ATC a wind of ~~140/07~~ 190 / 15*	*accepted*

		should select Vapp+5 at that stage.	*which indicates a tailwind component of ~~6~~ (2) knots, the crew should select Vapp+5 at that stage.*	
20	3.0 / CONCLUSION / 39	*3.1.18 ATC reported landing wind (CVR) on R/W 29 wind 190/15 Knots on landing clearance will result in a tail wind component of 12.9 Knots tail wind and 7.5 Knots Cross wind.*	*3.1.18 ATC reported landing wind (CVR) on R/W 29 wind 190/15 Knots on landing clearance will result in a tail wind component of ~~12.9~~ (2) Knots tail wind and ~~7.5~~ (15) Knots Cross wind.*	*accepted*
21	3.0 / CONCLUSION / 39	*3.1.21. Jordan Aviation Operation depends very much on lease out to foreign operators and sometimes to use strange airfields operation. Jordan aviation training policy does not account for Route and Airfield competency.*		*No comments received*
22	3.3 / CONTRIBUTING FACTORS / 40	*Touchdown with a closure rate of 3.0 fps,*	*~~Touchdown with a closure rate of 3.0 fps~~,*	*Rejected but amended with better explanation*
23	3.3 / CONTRIBUTING FACTORS / 40	*7-knot tailwind.*	*~~7-knot tailwind.~~*	*accepted*
24	3.3 / CONTRIBUTING FACTORS / 40	*- Oscillations were visible in lateral acceleration, normal load factor, and* *- longitudinal acceleration starting around initial main gear ground contact. It is possible that, before the main gear air/ground discrete transitioned to GROUND,* *- high frequency oscillations*	*~~- Oscillations were visible in lateral acceleration, normal load factor, and~~* *~~- longitudinal acceleration starting around initial main gear ground contact. It is possible that, before the main gear air/ground discrete transitioned to GROUND,~~* *~~- high frequency oscillations~~*	*accepted*