Final Investigation Report on Accident to M/s Jet Airways India (Pvt.) Ltd. Boeing B 737-800 Aircraft VT-JGA at Khajuraho Airport on 13-04-2015

COMMITTEE OF INQUIRY VT-JGA

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Foreword

In accordance with Annex 13 to the Convention on International Civil Aviation Organization (ICAO) and Rule 3 of Aircraft (Investigation of Accidents and Incidents), Rules 2012, the sole objective of the investigation of an accident shall be the prevention of accidents and not apportion blame or liability.

This document has been prepared based upon the evidences collected during the investigation, opinion obtained from the experts and laboratory examination of various components. Consequently, the use of this report for any purpose other than for the prevention of future accidents could lead to erroneous interpretations.

Glossary

AAI	Airports Authority of India
AAIB	Aircraft Accident Investigation Bureau, India
AED	Aircraft Engineering Directorate, DGCA
A/F	Airframe Hours
AFE	Airfield Elevation
AME	Aircraft Maintenance Engineer
AMM	Aircraft Maintenance Manual
AMSL	Above Mean Sea Level
AOG	Aircraft On Ground
AOP	Air Operator Permit
APU	Auxiliary Power Unit
ATC	Air Traffic Control
ATD	Actual Time of Departure
ATPL	Airline Transport Pilot Licence
AUW	All Up Weight
AVSEC	Aviation Security
BR &T ,NDI	Barkhausen Techniques , Non Destructive Inspection
CAR	Civil Aviation Requirements
CCIC	Cabin Crew In-Charge
CFT	Crash Fire Tender
C of A	Certificate of Airworthiness
CRM	Crew Resource Management
CG	Centre of Gravity
CPL	Commercial Pilot License
CVR	Cockpit Voice Recorder
DAW	Director of Airworthiness
DGCA	Directorate General of Civil Aviation
DFDR	Digital Flight Data Recorder
DME	Distance Measuring Equipment
DVOR	Doppler Very High Frequency Omni Range
ETA	Expected Time of Arrival
EASA	European Aviation Safety Agency
EQA	External Quality Assessment
FAA	Federal Aviation Administration
FRTO	Flight Radio Telephone Operator's License
GP	Glide Path
HIRL	High Intensity Runway Lights
ICAO	International Civil Aviation Organization
IATA	International Air Transport Association
IFR	Instrument Flight Rule
ILS	Instrument Landing System
IR	Instrument Rating
IST	Indian Standard Time
L1	Left Front Door
L2	Left Rear Door

L/G	Landing Gear
LH	Left Hand
LP	Low Pressure
L & T	Load & Trim
LOPA	Layout of Passenger Accommodation
MACTOW	Mean Aerodynamic Chord Takeoff Weight
MLG	Main Landing Gear
NTSB	National Transportation Safety Board, USA
N1	Low Pressure Compressor Speed
N2	High Pressure Compressor Speed
NDB	Non-Directional (radio) beacon
PAPI	Precision Approach Path Indicator
PF	Pilot Flying
PM	Pilot Monitoring
PIC	Pilot In Command
PPC	Pilot Proficiency Check
Pax.	Passenger
R1	Right Front Door
R2	Right Rear Door
RFFS	Airport Rescue and Fire Fighting Services
RH	Right Hand
RWY	Runway
RTR	Radio Telephony
SALS	Short Approach Lighting System
SEP	Safety and Emergency Procedures
STOL	Supervised Takeoff & Landing
TCDS	Type Certificate Data Sheet
TLA	Throttle Lever Angle
TODA	Takeoff Distance Available
TORA	Takeoff Run Available
TSN	Time Since New
TWR	ATC Tower
VFR	Visual Flight Rule
VHF	Very High Frequency
VOR	Very High Frequency Omni Range
U/S	Un-serviceable
UTC	Co-ordinated Universal Time

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FINAL INVESTIGATION REPORT ON ACCIDENT TO M/s JET AIRWAYS INDIA (PVT.) LTD. BOEING B 737-800 AIRCRAFT VT-JGA AT KHAJURAHO AIRPORT ON 13-04-2015

1.	Aircraft	Type	Boeing 737-800
		Nationality	Indian
		Registration	VT-JGA
2.	Owner & Operator		M/s Jet Airways India (Pvt.) Ltd., Mumbai
3.	Pilot – in –Command		ALTP Holder
	Extent of injuries		NIL
4.	Co Pilot		CPL Holder
	Extent of injuries		NIL
5.	Date of Accident		13-04-2015
6.	Time of Accident		0751 UTC
7.	Place of Accident		Runway 19, Khajuraho Airport
8.	Last point of Departure		Varanasi Airport
9.	Intended landing place		Khajuraho Airport
10.	No. of Passengers on board		59
	Extent of injuries		NIL
11.	Type of Operation		Scheduled Passenger Flight
12.	Phase of Operation		During landing Roll
13.	Type of Accident		LH Main Landing Gear collapsed due failure of Aft Landing Gear Trunnion Pin.
14.	Co-ordinates of Accident Site		Lat 24° 49 ' 25.5" N Long 79° 55' 76 " E AMSL 713 feet

(All timings in the report is in UTC)

SUMMARY:

M/s Jet Airways B-737-800 aircraft VT-JGA flight 9W- 2423 (Delhi -Varanasi-Khajuraho –Delhi) was involved in an accident at Khajuraho Airport on 13.4.2015 at 0751 UTC (1321 IST). There were 59 passengers and 08 crew members (02 Cockpit Crew + 05 Cabin Crew +01 AME) on board the aircraft. The aircraft was under command of PIC having ALTP and Co-pilot having CPL. The aircraft got airborne from Varanasi Airport at 0715 UTC and the flight was normal till touch down at RWY 19 on Khajuraho Airport. PIC carried out ILS approach and landing on R/W 19 at Khajuraho Airport and the maximum G load recorded during landing was 1.65 G. During landing Roll, 15 seconds after touchdown, at speed 36 knots, left main landing gear aft trunnion pin broke and aircraft started deviating to the left of center line. The aircraft came to stop on runway with damage to the LH landing gear and resting on LH engine, Nose & RH landing Gear. Hydraulic fluid spillage occurred due to damage to LH main landing gear. Emergency evacuation was carried out on the runway. All four main doors escape slides & four emergency over wing windows were opened. However the passengers used two escape slides (L1 & L2) for evacuation. One cabin crew received minor injuries (bruises) during evacuation. There was no fire. The runway was closed after the accident as aircraft became disabled on the runway. Due to closure of runway one A-320 aircraft VT-ESE of Air India stuck at Khajuraho Airport which had landed before 9W-2423. The Jet airways aircraft was removed from runway on 16-04-2015 and airport opened for normal operation at 1115 UTC on same day.

Ministry of Civil Aviation vide order No. AV 15029/107/2015-DG dated June 2015 constituted a committee of inquiry to investigate the accident under Rule 11 (1) of Aircraft (Investigation of Accidents and Incidents), Rules 2012. The committee includes Sh. Amit Gupta Deputy Director-AED, DGCA as Chairman and Capt. Rajiv Yadav, FOI, DGCA & Sh. Manoj Kumar, Sr. AGM, Air India as member.

The Committee of inquiry determined the cause of accident as "The LH Aft landing Gear trunnion pin failed due to overload following fatigue growth. Crack initiation was in the heat affected area where excessive grinding was done at the time of overhaul. Initial crack growth is charterized by intergranular cracking (assisted by hydrogen embrittlement mechanism) until fatigue took over."

1. FACTUAL INFORMATION.

1.1 History of flight

M/s Jet Airways B-737-800 aircraft VT-JGA flight 9W- 2423 (Delhi -Varanasi-Khajuraho –Delhi) was involved in an accident on 13.4.2015 at 0751 UTC (1321 IST) after landing at Khajuraho Airport, when left main landing gear aft trunnion pin broke on runway. There were 59

passengers and 08 crew members (02 Cockpit Crew + 05 Cabin Crew +01 AME) on board the aircraft. The aircraft was under command of PIC having ALTP and Co-pilot having CPL. The aircraft got airborne from Varanasi Airport at 0715 UTC and the flight was normal till touch down at RWY 19 on Khajuraho Airport. PIC was pilot flying & Co-pilot was carrying out duty of Pilot Monitoring. PIC carried out ILS approach and landing on R/W 19 at Khajuraho Airport. Landing gear was extended at 1579ft AFE and as per DFDR it was down and locked. Flap 40 was selected at 1394ft AFE. At touchdown aircraft pitch was 4.39 °, vertical G 1.65 and touchdown speed was 120 kts (V_{ref} − 4kts). During landing Roll 15 seconds after touchdown at speed 36 knots left main landing gear aft trunnion pin broke and aircraft started deviating to the left of center line. The aircraft came to stop on runway with damage to the LH landing gear and resting on LH engine, Nose & RH landing Gear. Hydraulic fluid spillage occurred due to damage to LH main landing gear. Emergency evacuation was carried out on the runway. All four main doors escape slides & four emergency over wing windows were opened. However, the passengers used two escape slides (L1 & R1) for evacuation. One cabin crew received minor injuries (bruises) during evacuation. There was no fire and no fire extinguisher was used in the accident. The runway was closed after the accident as aircraft became disabled on the runway. The aircraft VT-JGA completed three sectors on date of accident i.e. Bengaluru- Delhi, Delhi- Varanasi and Varanasi- Khajuraho.

As per ATC officer statement the touch down was normal near PAPI on runway. Aircraft slowed down near TWY "C" and was given taxi instructions. At that point pilot told "STANDBY" and asked ATC to confirm landing gear collapsed on left side to which ATC replied observed smoke coming out. Pilot informed ATC regarding to evacuation on runway itself and asked the ATC assistance. CFT and other emergency services were sent to the aircraft.

Due to closure of Khajuraho runway, Air India A-320 aircraft VT-ESE (flight No. AI 406, Agra-Khajuraho) which landed at 07:44:50 UTC before 9W-2423 stuck at Khajuraho Airport. The disabled Jet airways aircraft was removed from runway at 1115 UTC on 16-04-2015 and airport opened for normal operation.

1.2 Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	NIL	NIL	NIL
Serious	NIL	NIL	NIL
Minor	1	NIL	NIL
None	2+4+1	59	NIL

1.3 Damage to aircraft.

The aircraft sustained substantial damage. Following main damages occurred to the aircraft.

1. LH main landing gear aft trunnion pin found sheared off. The aft end of the LH MLG has travelled up and (puncturing the composite panels) protruding out and above the aft wing surface (walking beam visible above the wing surface).The damage limited to the composite panels and their non-structural support frames.
2. The support beam is damaged due L/G travel.
3. Hangar link assembly found a drift.
4. Hangar link mount found dislocated.
5. Side strut assembly twisted
6. Door attachment bracket and door found damaged.
7. MLG stub beam (structural member) between the aft spar and the MLG support beam lower forward attach lug ripped off.
8. Aircraft resting on the LH engine.

1.4 Other damage: NIL

1.5 Personnel information:

1.5.1 Pilot – in – Command:

Age/ date of Birth	32 Yrs/27.08.1982
Sex	Male
Licence Type	ATPL
Validity	29.11.2015
Type endorsements	B737 PIC
Aircraft Rating	B 737 -700/800/900
Date of Joining Jet Airways	03.01.2005
Instrument Rating & validity	26.05.2014 valid up to 25.05.2015
FRTO validity	10.11.2017
RTR validity	22.11.2021
Date of Medical Examination & validity	13.11.2014 valid up to 12.11.15
Date of Last Line/Route Check & validity	04.01.2015 valid up to 03.01.2016
Date of last Proficiency/IR Check	IR – 26.05.2014 PPC- 10.11.2014
Date of last English language Proficiency	05.04.14
Date of Last CRM Training	24.04.2014

Date of last Monsoon Training	24.04.2014
Date of last Simulator Refresher/Test	IR – 26.05.14 PPC- 10.11.14
Date of Refresher & validity	24.04.14 valid up to 23.04.15
Date of AVSEC & validity	26.04.14 valid up to 25.04.16
Date of SEP training & validity	24.04.14 valid up to 23.04.15
Total flying Experience on all types	8290:10 Hrs.
Total Experience on Type: PIC and Co-Pilot	4402:40 Hrs.
For Last 1 Year	937:43 Hrs.
Total in last 90 days	212:02 Hrs.
For Last 30 days	46:43 Hrs.
For Last 7 days	20:13 Hrs.
For the last 24 hrs	8:30 Hrs.
Rest Period Prior to duty Flight	19:30 Hrs.
Check Pilot Rating	Jan 2014

1.5.2 Co-Pilot:

Age/ date of Birth	28 Yrs/ 15.01.1987
Sex	Male
Licence Type	CPL
Validity	17.07.2018
Type endorsements Co-Pilot	B737
Aircraft Rating	B 737 -700/800/900
Date of Joining Jet Airways	24.12.2010
Instrument Rating & validity	01.12.15 valid up to 30.11.16
FRTO & validity	17.07.18
RTR & validity	13.09.15
Date of Medical Examination & validity	10.11.14 valid up to 09.11.15
Date of Last Line/Route Check & validity	29.12.14 valid up to 28.12.15
Date of last Proficiency/IR Check	IR – 02.12.14 PPC-02.12.14
Date of last English language Proficiency	20.10.14 valid up to 09.10.2020
Date of Last CRM Training	06.01.2015
Date of last Monsoon Training	06.01.2015
Date of last Simulator Refresher/Test	IR – 02.12.14 PPC-02.12.14
Date of Refresher & validity	08.01.15 valid up to 07.01.16
Date of AVSEC & validity	09.01.14 valid up to 08.01.16

Date of SEP training & validity	07.01.15 valid up to 06.01.16
Total flying Experience on all types	3393:14 Hrs.
Total Experience on Type: Co-Pilot	3134:35 Hrs.
For Last 1 Year	760:04 Hrs.
Total in last 90 days	226:58 Hrs.
For Last 30 days	83:40 Hrs.
For Last 7 days	15:58 Hrs.
For the last 24 hrs	4:32 Hrs.
Rest Period Prior to duty Flight	>24 Hrs

1.5.3 Cabin Crew:

Cabin Crew Seat Location		**CCIC L1**	**L2**	**R3**	**R2**	**R1**
Date of Birth		15.08.1982	13.08.1988	02.09.1992	10.07.1995	11.05.1994
Date of joining Jet Airways		15.09.2005	24.04.2011	26.12.14	10.09.13	02.09.13
Date of Initial training on B737-800 a/c		24.10.05 - 14.02.05	05.01.15-15.02.15	12.01.15-16.01.15	24.10.13-25.11.13	17.10.13-15.11.13
SEP initial Training		24.10.05-14.02.05	05.01.15-15.02.15	12.01.15-16.01.15	24.10.13-25.11.13	17.10.13-15.11.13
DG initial Training		13.10.05	03.01.2015	04.01.2015	09.10.2013	01.10.13
Date of initial Practical training	Wet drill	19.11.05	16.01.15	14.03.13	08.11.13	08.11.13
	Fire drill	18.11.05	16.01.15	14.03.13	08.11.13	8.11.13
	Escape slide drill	17.11.05	16.01.15	16.04.13	08.11.13	8.11.13

1.5.4 Aircraft Maintenance Engineer:

Age	47
Sex	Male
Date of Joining Jet Airways	14th Dec.2000
Date of becoming AME	04th July 2005
License Date of Issue/ Validity	26 June 2006 / 03rd July 2017
Training on Cat. 'A' Training on Cat. 'C'	Boeing 737-700/800/900, CRJ - 200 CFM 56-7 / GE C F34-3
Total Aviation Experience	22 years 02 months
Total Experience as AME	10 years 06 months

1.6 Aircraft Information

1.6.1 General Description:

Boeing 737-800 is a Twin engine aircraft fitted with CFM 56-7B Engine and is manufactured by CFM. This aircraft is certified in Normal category, for day and night operation under VFR & IFR. The maximum operating altitude is 41000 feet. Aircraft length is 39.472 meters, wingspan is 35.8 meters and height of this aircraft is 12.459 meters. This airplane is certificated in the Transport Category, FAR Part 25 and Part 36.

1.6.1 Construction: The airframe structure is fabricated, in general, of high-strength aluminum alloys. Steel, titanium, and other FAA approved materials are also used where required. Magnesium alloy is not used in primary or secondary structural application. Aluminum alloy sheet stock are clad for gages less than 0.063 inch thick. The fuselage is a semi-monocoque structure with zee-type frames and skin stiffened with hat-type stiffeners. The fuselage skin panels are made of longitudinal stiffeners mechanically fastened to sheets or plates. Circumferential tear straps and doublers are used where necessary. A nacelle encloses each engine. A strut attached to the wing holds the engine and nacelle. A firewall made of corrosion-resistant steel or titanium alloy isolates each nacelle from its strut.

The wing is made into one piece which extends through the fuselage. The wing to body attachment is permanent. The primary wing structure is an aluminum alloy skin stiffened by stringers made of extruded aluminum alloy. The spars primarily carry the shear loads. The skin and stringers carry most of the bending loads. The wing is also an integral fuel tank. The trailing edge ribs are made of aluminum alloy. The upper surface is made of an aluminum alloy skin and reinforced honeycomb sandwich of fiberglass and graphite. The lower surface is made of an aluminum alloy skin with a reinforced 10 honeycomb sandwich of aramid/graphite and fiber glass/graphite. There is access to inside of the trailing edge for inspection, maintenance, and

repair. The fixed structure of the leading edge is made of aluminum alloy, fiberglass, or composite fiber glass and aramid, as necessary. No winglets are installed on the aircraft.

The aircraft was certified for 189 passengers. However, VT-JGA was configured to 12 Business class and 156 economy-class passengers' seat (total 168 passenger).

1.6.2 Aircraft Technical Information

Name of Operator	Jet Airways
Aircraft Type	B737-800
Registration Marking & S.No.	VT-JGA, MSN : 30410
Model	B737-85R
Date of Manufacture	Oct-2002
Date of Arrival in India	16-11-2002
Hours and Cycle at Arrival in India	28:27 Hrs. & 11Cycles
Date of Induction in Jet Airways	21-11-2002
Validity of Certificate of Airworthiness	Unlimited.
C of A Category	Normal
C of A Sub Division	Passenger/ Mail/Goods
ARC was valid	13.10.2015
Total Flying Hrs / Cycles since manufacture as on 13.04.2015	TSN: 37630:18 Hrs. CSN: 27791 Cycles
The last major check/inspection carried out on the aircraft	C6 check done on 28.11.2013 at BOM
Total Flying Hrs/cycles/landing at Last major periodic inspection	TSI: 4412:55 Hrs. CSI: 3305 Cycles
Last periodic inspection	A2 check done on 09.03.15 at BOM
CVR & DFDR details	DFDR P/N: 2100-4043-00, S/N: 000600678 CVR P/N: 2100-1020-00, S/N: 000265815
SELCAL Code	JL-AR
Mode S Transponder	1000 0000 0000 0000 1111 1011
Type of Engine	CFM 56 -7BM24

Weight and Balance Information:

The Details of basic weight schedule were as follows:-

Aircraft Empty Weight	41113 Kgs
Max fuel capacity(At density of .785 kg/litre)	20446 Kgs
Maximum Takeoff weight	68400 Kgs
Empty weight CG (cm)	657.63inches or 1670.38 cm
Datum (from forward of front spar)	540 inches or 13.716 m
Maximum Permissible number of Passengers	LOPA: 168 & TCDS: 189
Number of flight Crew	2 Pilots, 5 cabin attendant

Weight	Actual Weights for Flight on 13-04-2015 in Kgs	Maximum Permissible weight in Kgs
Take-off Weight	53177	68400
Landing Weight	51592	65317
Zero fuel Weight	48223	61688

Computerized Load & Trim sheet was made for the flight**.** The Details of basic weight schedule were as follows:-

There was total of 59 Passengers on board the aircraft. To facilitate the calculation of the position of the center of gravity (CG), the passenger cabin is divided into six sections, 0A, 0B, 0C, 0D, 0E, 0F.

Zone	Actual Seating
0A	0
0B	19
0C	5
0D	3
0E	18
0F	14

The Boeing 737 has two lower cargo compartments for Baggage & Cargo. A forward cargo compartment, which is divided in hold #1 and hold #2 and an aft cargo compartment consisting

of hold #3 and hold #4. Total baggage load was 633 Kgs & Passenger load was 4425 Kgs. Total Traffic load was 5058 Kgs.

Cargo Hold	Actual (Kg)
1	300
2	97
3	0
4	236

The Middle Aerodynamic Chord (MACTOW) was calculated as 25.77 % and Stabilizer trim for takeoff was calculated as 4.25 degrees. Flap for takeoff was calculated as 05 °.

Dry Operating weight for the flight was 43175 Kgs. Take off fuel was 4944 Kgs, Trip fuel was 1585 Kgs and Taxi out fuel was 156 Kgs. Aircraft was under load of 13455 Kgs.

As a precautionary measures, after accident 4200 liters of fuel was de- fueled from aircraft by Indian Oil Corporation Limited at Khajuraho on 14-04-2015.

Aircraft CG was within the prescribed limit during takeoff and landing.

1.7 Meteorological information:

Class III Met office is available at Khajuraho. The time of accident was 0751 UTC.

At the time 0600 UTC, the visibility of 6000 meters, temperature 28 degree, dew point 18 and QNH 1015 Hpa /29.99 " Hg, winds 240/4kts.Clouds Scattered at 1000ft (3000m).

At the time 0700 UTC, the visibility of 6000 meters, temperature 30 degree, dew point 17 and QNH 1014 Hpa/29.96 " Hg, winds 070/02kts.Clouds Scattered at 2500 ft (750 m) and Broken at 1000ft (3000m).

At the time 0800 UTC, the visibility of 6000 meters, temperature 30 degree, dew point 17 , QNH 1013 Hpa/29.93 " Hg , winds 140/4kts.Clouds Scattered at 2500 ft (750 m) and Broken at 1000ft (3000m).

1.8 Aids to navigation:

Khajuraho airport is equipped with VOR, Glide Path, DME and NDB. The Runway Direction is 19 and 01. ILS Cat 1 is installed on Runway 19 only & ILS frequency 110.7 MHz. ILS was calibrated on 16-12-2014 and was working normal on date of accident. PAPI was installed on both 01 & 19 Runway. The VOR –DME Frequency is 116.40 MHz and NDB is 403 KHz. No problems with any navigational aids were reported before accident.

1.9 Communications:

The Communication frequencies at Khajuraho is as given below. The aircraft was in contact with Khajuraho ATC. From the tape transcript it was apparent that there was no communication problem between the Flight Crew & ATC from initial contact till stopping the aircraft.

No.	Service Designator	Call Sign	Frequency
1.	TWR	Khajuraho Tower	118.15 MHz
2.	DVOR	KKJ	116.40 MHz
3.	DME	KKJ	1135/1198 MHz
4.	NDB	KJ	403 KHz
5.	LLZ 19 ILS CAT-1	IKJR	110.7 MHz
6.	GP	---	330.2 KHz
7.	DME (ILS)	IKJR	1068 /1005 MHz

1.10 Airport information.

Khajuraho Civil Airport (IATA: HJR, ICAO: VAKJ) is a civil domestic airport in Khajuraho, Chhatarpur District, Madhya Pradesh operated by Airports Authority of India. The elevation of airport is 728 ft / 222 m AMSL The airport is licensed by DGCA for both IFR and VFR traffic.

Runway Direction is 19 and 01. ILS CAT- 1, SALS is installed on Runway 19 and PAPI, HIRL on both ends of 01 & 19. The Runway is made of Asphalt. The Airport Reference point is 24°49"11.'8N, 79°55"6.4' E. The Airport Rescue and Fire Fighting Services (RFFS) was Category '7', Code No. '4' and Code letter "D". The ILS was last calibrated on 16-12-2014 and was working normal on date of accident. Varanasi Airport is situated at air distance of 165 Nm.

The Runway declared distance in meters are

Rwy	TODA	TORA	ASDA	LDA
01	2286	2286	2286	1829
19	2286	2286	2286	2286

Threshold of Runway 01 was displaced 1,500 ft (457 m). After the accident the runway was closed from 13-04-2015 to 16-04-2015 (1115 UTC) due disabled Jet Airways aircraft blocking the runway.

1.11 Flight recorders.

The aircraft was fitted with Solid State CVR & DFDR as per table given below. The recorders showed no signs of damage. CVR & DFDR were downloaded and the readouts for both units were successful. Data from both CVR & DFDR were downloaded and analyzed after the accident.

No.	Unit	Manufacturer	Part Number	Serial Number	Total Duration of Recording
1	CVR	L3 Communication Fairchild, USA	2100-1020-00	265815	02 Hrs 04 min
2	DFDR		2100-4043-00	600678	124 Hrs 18 min

1.11.1 Cockpit Voice Recorder (CVR)

The CVR readout was analyzed and following are the salient findings.

1. The landing was carried out by PIC and co-pilot was doing the duties of monitoring the instruments.
2. At 1000 feet above, the aircraft was stabilized and winds were calm.
3. Approach and Landing checklist were carried out by the flight crew.
4. ATC cleared aircraft to land on Runway 19.
5. Aircraft landed on Runway at 075114 UTC.
6. At 075128 UTC, with ground speed 36 knots, LH Landing gear collapsed.
7. PIC informed ATC about left main gear collapse.
8. ATC confirmed the crew about left hand side landing gear collapse and informed crew about some smoke coming out at landing Gear area.
9. PIC informed ATC that they are carrying out evacuation on the runway.
10. PIC requested ATC to send all emergency services to the aircraft.
11. The flight crew carried out Evacuation checklist and advised cabin crew to evacuate.

1.11.2 Flight Data Recorder (FDR)

The DFDR readout was analyzed and following are the salient findings.

GMT	Event	
07:48:50	Landing Gear down at Rad. Alt 1751 ft. and Flap 15.	
07:49:11	Flap changed to 40 at Rad. Alt 1578 ft.	
07:49:49	Autopilot Disengaged at Radio Altitude 904	
07:50:06 to 07:50:13	Vertical Speed between -1005 to -1095 ft/sec.	
07:51:13	LH & RH Landing Gear Touched Down on the runway	
07:51:13	Speed Brake applied	
07:51:14	Nose Landing Gear touched down. Flap 40, Normal Accn. 1.65 G, Brake Press Left 9, Brake Press Right 5, Vertical Speed -312 ft, Ground Speed 132 Knots, CAS 121 Knots and Heading 194, Pitch 4.39	
07:51:17	Eng. Reverser 2 deployed	
07:51:18	Eng. Reverser 1 deployed	
07:51:25	Speed Brake released	
07:51:28	Aircraft Roll changes from 0.88 to -5.27 at Heading 193, Ground Speed 36 Knots.	
07:51:29	Engine Reverser 2 and 1 stowed	
	Brake Pressure L/R	Brake Position. L/R
07:51:29	65/96	6/7
07:51:30	59/1437	6/46
07:51:31	458/2010	17/62
07:51:32	194/1627	10/51
07:51:33	252/1938	12/60
07:51:34	282/773	12/27
07:51:35	-2/1332	4/43
07:51:35	Roll reduced to -4.92 and stayed same upto end of recording	
07:51:44	Ground Speed 0	
07:51:45 to 07:51:51	Master Warning	
07:52:52 to 07:53:16	Master Warning	
07:53:16	End of recording. The recordings are: - Heading 192, Flap 40, Brake Press Left- 2169, Brake Press Right- 1881, Brake Position LH 67 , Brake Position RH 59, , Eng 1 (N1 – 20.88 %, N2- 60.88%, TLA 35.16, Fuel Cut off- Run), Eng 2 (N1 – 21.25 %, N2- 61, TLA 34.8, Fuel Cut off- Run), Master Caution Warning, Master Warning .	
	There was No indication of Engine Fire Warning during the collapse of Landing Gear.	

1.12 Wreckage and impact information.

The aircraft touch down at Khajuraho Airport on RWY 19. After touch down the aircraft started deviating to the left of center line and came to halt with damage to the port landing gear and resting on LH engine, Nose & RH Landing Gear. Hydraulic fluid spillage occurred on the runway due to damage to port main landing gear.

Following are the distance measured with help of DFDR & Ground marks.

1. Touch down point to aircraft nose halt: 1182 meters.
2. Touch down point to aircraft halt: 1157 meters.
3. Engine rub marks: 116 meters.
4. Tyre Rub marks: 150 meters.
5. Nose wheel position to center line: 8.3 meters to left.

1.13 Medical and pathological Information:

Prior to operating the flight both the Cockpit crew & Cabin Crew had undergone pre-flight medicals / Breath analyser test at Delhi and were found negative. However, Post flight medical Examination of Cockpit Crew & Cabin Crew were not carried out after the accident at Khajuraho Airport. As per Jet Airways Flight Safety Manual, post flight medical examination of crew is mandatory in case of accident.

1.14 Fire:

There was no pre or post impact fire.

1.15 Survival aspects:

The accident was survivable. After landing, PIC announced to cabin crew on PA three time "Evacuate". The L1, L2, R1 and R2 door slides were deployed for egress, and both right and left over wing window exits were opened. The passengers and crew evacuated the airplane using the L1 and L2 door slides. R1 slide got inflated and detached from aircraft and no evacuation was carried out using R2 slide & over wing exits.

The left L1 & L2 slides were used by cabin crew for evacuation even though there was hydraulic leak on LH landing gear & LH Engine touching the runway. As per photographs, passengers were seen holding hand baggage & wearing shoes. However, as per statement one cabin crew received minor injury during evacuation.

1.16 Tests and research:

The failed LH aft landing Gear Trunnion pin was tested in DGCA and NTSB, USA. Along with LH, the RH aft landing Gear Trunnion pin was also send to NTSB, USA for examination.

1.16.1 Failure Investigation by Failure Analysis Lab, DGCA

Failure Analysis Lab, DGCA carried out metrological analysis of failed trunnion pin. The lab report reveals that the "*the trunnion pin has failed in fatigue originating from black strip which is probably a pre-existed crack*".

1.16.2 Failure Investigation by NTSB, USA

The failed LH trunnion pin & RH trunnion pin (P/No.161A1192-3) was send to NTSB, USA for examination. The examination report reveals

1.16.2.1 LH MLG aft Trunnion Pin, S/N: E2410

a) *Chicken wire cracking was observed on the chrome plating and an MPI revealed the presence of cracking in the base metal.*
b) *The fractured aft trunnion pin contained an intergranular crack on the fracture face measuring 0.018 inch from the outer diameter (OD). Fatigue cracking was observed emanating 0.22 inch from the intergranular crack.*
c) *Fracture initiation occurred by heat induced cracking which propagated during processing by a hydrogen embrittlement mechanism. Once in service, fatigue cracking initiated off of the existing crack until final fracture by ductile separation.*
d) *Nital etching of the forward half of the pin revealed over-tempered martensite resulting from exposure to temperatures at or above the tempering temperature.*
e) *Tensile residual stress in the areas of over-tempered martensite is indicative of thermal damage to the base metal.*
f) *Fracture of the aft trunnion pin was probably the result of excessive grinding of the chrome plate.*

1.16.2.2 RH MLG aft Trunnion Pin, S/N: E2338

The Barkhausen inspection conducted at the time of the EQA and BR&T NDI, revealed no indications of burning of the base metal. BR&T metallurgy examination results:

a) *Etching of the chrome layer on the RH MLG aft trunnion pin was performed in order to examine the surface for cracking. "Chicken wire" cracking was observed over the entire chrome surface of the pin.*
b) *After the chrome etch examination, the pin was completely stripped of chrome and subjected to a nital etch inspection. No nital indications indicative of thermal damage were observed.*

1.17 Organizational and management information:

M/s Jet Airways (India) Ltd. is a Scheduled Airlines having DGCA SOP No. S-6A in Category Passenger and cargo which commenced operations on 5th May 1993. The airlines operates a fleet of 102 aircraft, which includes 05 Boeing 777-300 ER aircraft, 08 Airbus A330-200 aircraft, 67 next generation Boeing 737-700/800/900 aircraft and 18 ATR 72-500 turboprop aircraft. M/s Jet Airways operates approx. 68 destinations (47 Domestic + 21 international). Jet Airways has approx. 13900 employees in the organization.

1.18 Additional information:

1.18.1 Disable Aircraft Removal

As per DGCA CAR Section -4 Series B Part -1 dated 31st July 2016, para 2.10 "Disabled aircraft removal"

- The disabled aircraft removal plan shall be developed by each Airport and included in the Airport manual.
- Information concerning the capability to remove an aircraft disabled on or adjacent to the movement area shall be included in the plan. The telephone/telex number(s) of the office of the Airport coordinator of operations for the removal of a disabled aircraft shall be made available, on request, to aircraft operators.

DGCA Air Safety Circular 06 of 1994 "Disabled aircraft removal plan" Airport authorities are required to prepare the disabled aircraft removal plans for the airport under their jurisdiction and forward a copy each of such plans to DGCA. All operators should include necessary information on this subject in their Operations Manual and the concerned officials should be made aware of their responsibility.

ICAO had also published in Annex 14, Airport Services Manual, Document 9137 –AN / 898, Part 5 regarding Removal of Disabled Aircraft. Khajuraho Airport Manual contains Disabled aircraft removal plan.

1.18.2 Selection of M/s ST Aerospace, Oslo as vendor by Jet Airways

The Selection Procedure of Vendor was defined in Jet Airways Quality Department Manual Chapter 2 "Maintenance Contractor Selection Procedure". As per para 2.10.5.1,"On receipt of vendor approval request from Material manager/User Department, Policy and standard group shall evaluate credentials of the proposed vendor through a desktop audit of documents supplied as per vendor evaluation form".

However, the manual doesn't restrict to Jet Airways to carryout work at DGCA CAR-145 approved organization.

1.18.3 Overhaul of Landing Gear by M/s ST Aerospace Solutions (Europe) A/S, Oslo.

The installed Landing Gears VT-JGA were overhauled by M/s ST Aerospace Solutions (Europe) A/S, Oslo, Norway. The LH landing Gear Trunnion Pin Sl. No. E2410 and RH landing Gear Trunnion Pin Sl. No. E2338 was overhauled on 27th March2012. M/s ST Aerospace, Oslo was approved by Danish Transport Authority vide DK.145.0092 & FAA vide SCGZ360Y valid upto 31st October 2013. However, the overhaul facility was not approved under CAR 145 by DGCA, India. The Landing Gear Pin was installed along with Landing Gear on 30-04-2012 by Jet Airways at Delhi.

The overhaul process of Trunnion Pin includes mainly

1. Cleaning
2. Removal of paint
3. Removal of Cadmium coating
4. Removal of Chrome coating
5. Machining
6. Etch Inspection
7. Megna Flux Inspection
8. Shot Peening
9. Chrome Plating
10. Machining
11. Heat Treatment
12. Megna Flux Inspection
13. Cadmium treatment
14. Megna Flux Inspection
15. Chrome Treatment
16. Primer & Paint.

The overhaul process sheets of Trunnion Pin were send to NTSB and it was of found that the appropriate procedures as outlined for the landing gear overhaul were carried out. Both the left

and right pins were apparently processed at the same time as seen from the dates of overhaul. Some manual grinding was done to the left pin and the right pin was fine minus the chicken wire cracking.

1.18.4 Sequence of Engineering Events after accident

On 13th April 2016 VT-JGA while operating 9W-723 from Varanasi to Khajuraho, the LH MLG failure after landing at Khajuraho. The runway was blocked after accident. DGCA team & Jet Airways AOG recovery team was rushed to Khajuraho Airport after accident.

Following were the site observations:-

1. The aircraft was resting on its LH engine, nose and RH MLG on the runway.
2. The LH MLG Aft end was found broken from its mount on the support beam and projecting up and forward through the honeycomb composite panel on LH upper wing surface.
3. Closer inspection revealed half of the Aft MLG trunnion pin stuck in the MLG Aft end and other end in the support beam mounted bearing.
4. The aft trunnion pin had sheared off causing the accident.

Following main work carried out for recovery of aircraft.

1. After obtaining clearance, aircraft was defueled.
2. The broken pieces of the Trunnion pin were removed from LH Gear.
3. The side brace assembly was removed as it was deformed.
4. The aircraft was lifted from the LH MLG jack point to lift the engine clear from the ground.
5. As the aircraft lifted the LH MLG was swung back into its original position.
6. New side brace assembly and aft trunnion pin were installed to restore the MLG structural integrity.
7. The aircraft was towed on 16/04/2015 to clear the runway on to apron to make the airport operational.
8. From 18-04-2015 to 24-04-2015, team of Engineers from Tech SVCs, structural repair, A & C, NDT and some technicians. The job carried out during this period consisted of preparing a detailed list of damage suffered and analysis of repair / recovery action required.
9. A survey of damage suffered was carried out by an AOG team of BOEING.
10. Detailed repair and maintenance work was carried out at Khajuraho to make aircraft serviceable for ferry flight to Delhi.
11. Aircraft carried out ferry flight from Khajuraho to Delhi on 21st May 2015 without LH Engine change under special flight permit issued by DAW Mumbai.

12. After landing at Delhi, the LH engine along with other components were changed to made aircraft serviceable.
13. Completion Certificate issued jointly by Boeing & Jet Airways on 26th May 2015.
14. Aircraft declared serviceable on 02 June 2015 & CRS issued.

1.18.6 Passenger Evacuation after accident VT-JGA.

Based on the statements by the Captain, Co-Pilot, CCIC (01), Cabin Crews (04) and AME a circumstances before, during and after the emergency evacuation were as outlined below. There are 05 Cabin Crew including CCIC. They had given duties at door L1 (Left Front), L2 (Left Rear), R1 (Right Front), R2 (Right Rear) and Over-wing exit window. Passengers and crew were evacuated through L1 & L2 escape slides. However, both side over-wing exits windows and R1 & R2 doors were operated.

(1.) PIC & Co-Pilot

After landing, left Landing Gear collapsed. Brakes were applied and aircraft was brought to a complete stop on the runway. ATC confirmed about left landing gear collapse and informed about smoke coming from LH Landing Gear area. Decided to carryout evacuation on runway & informed the cabin crew accordingly. Carried out checklist and came out from cockpit and waited for passengers to evacuate from L1. PIC checked the aircraft & lavatory and evacuated last. Passengers on ground were advised to move away from aircraft.

(2.) CCIC (Positioned for L1)

After landing, PIC advised cabin crew to station on PA system. Aircraft Power went off and emergency lights came on. PIC ordered an evacuation and CCIC initiated passenger evacuation procedures. Door L1 was opened in armed condition and checked for external conditions. The escape chute inflated and passengers started evacuation from L1. In the meantime, the cabin crew at R1 informed that the escape chute inflated and got detached from aircraft.

(3.) Cabin Crew (Positioned for R1)

The cabin crew when opened R1, the slide got inflated and detached from the aircraft. The R1 door and passengers were directed to L1 door. While directing passengers to L1 door, there was minor injury at right knee due passenger baggage.

(4.) Cabin Crew (Positioned for over wing)

The cabin crew opened both Left & Right hand side over wing exits. However, there was no evacuation from the over wing exits.

(5.) Cabin Crew (Positioned for L2)

The cabin crew once heard the evacuate command, opened L2 door in armed condition. Door L2 was opened in armed condition and checked for external conditions. The escape chute inflated and passengers started evacuation from L2 door.

(6) Cabin Crew (Positioned at R2)

The cabin crew once heard the evacuate command, opened R2 door in armed condition. R2 door was opened in armed condition and checked for external conditions. The escape chute inflated but no passenger evacuated from R2 door.

(7) Aircraft Maintenance Engineer (on board)

As per the on-board AME statement, he felt hard landing with bumps on touch down at Khajuraho. Thereafter a loud sound was heard. Aircraft stopped on the mid of runway after few minutes. Thereafter, cabin crew announced evacuation on PA. He noticed all four escape slides deployed by cabin crew and observed heavy passenger rush from L1 door. R1 escape slide was found lying on ground with inflated condition and hence no evacuation was carried out from R1 door. All four over wing exit doors were also opened by crew. However, no passenger was evacuated from the over wing exit doors. On ground he noticed the fire services surrounding the aircraft. Hydraulic fluid spray was observed from LH main landing gear area. No fuel or engine oil leak was observed. No firefighting equipment was used.

1.18.7 Hard Landing

A hard landing typically occurs when the sink rate is high and the aircraft touches down on the runway with a thud instead of doing a smooth transition onto ground. An indication of a hard landing on the main landing gear is a peak recorded vertical acceleration that exceeds 2.1 G (incremental 1.1 G).

As per Jet Airways AMM Chapter 05-51-01

Quote

For landing at or below the maximum design landing weight on airplanes with flight data recording systems capable of at least least eight (8) samples per second, the following can be used: An indication of a hard landing on the main landing gear is a peak recorded vertical acceleration that exceeds 2.1 G (incremental 1.1 G). This vertical accelerometer data must be measured by the flight data recorder accelerometer at a data sampling rate of at least eight (8) samples per second. This vertical acceleration G-level threshold is valid for a conventional

landing with impact with no more than two (2) degrees of airplane roll, main landing gear touchdown first and normal rotation onto the nose gear. For a hard landing that is a hard nose landing or is accompanied by more than two (2) degrees of roll at the time of main landing gear impact, the recorded peak acceleration can be significantly less than 2.1 G, but a hard landing inspection may still be necessary.

(b) For landing at or below the maximum design landing weight on airplanes with flight data recording systems capable of at least sixteen (16) samples per second, the following can be used: An indication of a hard landing on the main landing gear is a peak recorded vertical acceleration that exceeds 2.2 G (incremental 1.2 G). This vertical accelerometer data must be measured by the flight data recorder accelerometer at a data sampling rate of at least sixteen (16) samples per second. This vertical acceleration G-level threshold is valid for a conventional landing with impact with no more than two (2) degrees of airplane roll, main landing gear touchdown first and normal rotation onto the nose gear. For a hard landing that is a hard nose landing or is accompanied by more than two (2) degrees of roll at the time of main landing gear impact, the recorded peak acceleration can be significantly less than 2.1 G, but a hard landing inspection may still be necessary.

Unquote

As per data given by Jet Airways, VT- JGA was involved in 10 incidents of landing above 2 G after overhauled trunnion pins were installed (30th April 2012).

S. No.	Date	Flight No.	Origin Apt	Destination Apt	Vert G-Airfase data
1.	28-10-2014	JAI2410	HYD	MAA	2.04
2.	04-08-2014	JAI411	BOM	BLR	2.13
3.	29-07-2014	JAI337	BOM	DEL	2.04
4.	16-05-2014	JAI 346	HYD	BOM	2.13
5.	29-04-2014	JAI434	IXE	BOM	2.41
6.	19-03-2014	JAI491	MAA	PNQ	2.2
7.	12-03-2014	JAI2378	RPR	BOM	2.1
8.	06-08-2013	JAI383	BOM	IXU	2
9.	21-04-2013	JAI807	DEL	BLR	2.1
10.	01-04-2013	JAI403	BOM	COK	2.09

In the above mentioned instances, all relevant AMM tasks were carried out.

1.18.8 Main Landing Gear Inspection after heavy Landing

As per Boeing maintenance manual SUBTASK 05-51-01-210-001, the landing Gear Inspection after heavy landing is as follows:-

Quote

(1) Examine the main landing gear areas as follows:
(a) The tires
(b) The wheels
(c) The shock strut of the main gear for damage, deformation or fluid leakage
(d) The doors and linkage of the main gear strut
(e) The top end of the shock strut for cracks and bolt distortion
(f) The landing gear beam.
(g) If the airplane departed the prepared surface, do the following:
1) Examine the brakes and wheels.
a) If there is dirt or debris in the spokes of the wheels or in the brake areas, remove the wheels and brakes.
b) If it is necessary to remove the wheels and brakes, examine the axles.
2) If you think that water or mud has reached the level of the wheel bearings or the axles, remove the wheels, brakes, and wheel speed transducers.
a) Examine the axles for damage.
b) Clean and remove the water, dirt, mud, or debris.

Unquote

1.18.7 Similar Accident to M/s Jet Airways VT-JGD on 03-03-2016 at Mumbai.

Jet Airways Boeing 737-900, registration VT-JGD while performing scheduled domestic passenger flight 9W-354 from Delhi to Mumbai on 03-03-2016 was involved in a landing accident at Chhatrapati Shivaji International (CSI) Airport, Mumbai. The aircraft had safely landed on runway 27 at 1622 UTC and had about to vacate the runway via taxiway N9 when the right main gear collapsed. There were no injuries but the aircraft sustained substantial damage.

Jet Airways vide its e- mail dated 23-11-2015 informed the committee that only two (02) sets of landing Gear were overhauled by ST Aerospace Solutions, Oslo. Two Aft (LH & RH) Landing gear pins were installed on VT-JGA (overhauled 27-04-2012) and other two were installed on VT-JGC (overhauled 29-11-2013). Jet Airways informed the committee that as precautionary measure, after the accident of VT-JGA, the pins from VT-JGC were removed and kept at quarentine stores.

However, after the accident of VT-JGD, M/s Jet Airways informed the committee that they had overhauled 03 set of landing Gear from ST Aerospace, Oslo installed on (VT-JGA, VT-JGC, VT-JGD) and 02 set of Nose landing Gear Trunnion Pin (VT-JGM and VT-JNL). Boeing after the accident of VT-JGD, advised Jet Airways to remove all the trunnion pins (Aft, front & Nose landing Gear) overhauled from ST Aerospace, Oslo. The failed pin of VT-JGD pin was overhauled on May 2013. All the pins were removed and send to NTSB for failure analysis.

1.18.8. DGCA CAR M Regulation

As per DGCA CAR M Sub part B Para MA.201 Rev1 dated 15th February 2015 page 22 para (g) "*Maintenance of large aircraft, aircraft used for commercial air transport and components thereof shall be carried out by a CAR -145 approved maintenance organization*".

As per DGCA CAR M Sub part E Para MA.501 Rev1 dated 15th February 2015 page 48 para 5
"For the purpose of CAR - M, a document equivalent to a CA Form 1 may be:

- *a release document issued by an organisation under the terms of a bilateral agreement signed by DGCA*
- *EASA Form ONE*
- *FAA Form 8130-3*
- *Any other form acceptable to DGCA.*"

ST Aerospace Solutions (Europe) A/S, Oslo was approved by FAA and EASA but not approved under CAR -145 by DGCA, India. However, the landing Gear overhauled was issued with EASA Form -1.

1.18.9. Construction of Landing Gear Trunnion Pin

The main purpose of Trunnion Pin is to support Landing Gear & pivot. The Landing Gear trunnion pin is made of high strength alloy steel material 4340M manufactured by Magellan Aerospace New York, Inc , USA. The heat treatment is 275-300 KSI per BAC5617 and material specification: BMS7-26.

The outside diameter finish is F-15.34 chromium plate in accordance with BAC 5709, class 3.F-19.451 apply wipe-on primer, BMS 10-79 type (iii) in accordance with BAC 5882 whereas Inside Diameter finish is F-15.01 cadmium-titanium alloy plate and apply chromate treatment in accordance with BAC5804. F-19.66 apply two coats of BMS 10-79 type (iii) primer in accordance with BAC 5882.

Landing Gear has has overhaul life of 21000 Flight Cycle/ 10 year and life limit of Trunnion Pin is 45000 Flight Cycle. Greasing method of landing Gear is through Grease Gun. Landing Gear lubrication interval is 560 cyc or 90 days.

Pin Details (as on 13.04.2015). Pin overhauled on 02.04.2012.

Installed on : 30.04.2012
TSN : 37126 Hrs.
TSO/TSI : 8895 Hrs.
CSN : 27429 cyc
CSO/CSI : 6724 cyc

The Landing Gear maintenance details are

- Aircraft completed three sectors on the date of event i.e. BLR-DEL-VNS-HJR.
- LH MLG last replaced on 30.04.2012
- Last Extended Transit inspection done on 11.04.2015 at BOM
- Last 30 days inspection done on 27.03.2015 at BOM
- Last A2 check done on 09.03.2015 at BOM
- Last C check done on 28.11.2013 at BOM.
- Landing gears (LH, RH, and NOSE) lubrication carried out on 14.02.2015 at BOM.

1.18.10 landing at Khajuraho Airport

- As per DGCA Air Safety circular 6 of 2014 revision 1, Khajuraho has been identified as Performance Limited Airfield.
- Runway length at Khajuraho is 7500 feet.
- Supervised takeoff and landing (STOL) is not permitted at this airfield.
- Captain was PF and first officer was PM.
- As per Jeppesen tailored chart 10-0A, crew has to use flap 40 and auto brake MAX for landing
- At the time of approach winds was 070/02kts and visibility 6kms.
- At 1000ft AFE and 500ft AFE gate aircraft was stabilized.
- There was no MEL revoked on the aircraft.
- Landing weight of the aircraft was 51.7 tons.

1.19 Useful or effective investigation techniques*:* NIL

2. ANALYSIS

2.1 SERVICEABILITY OF THE AIRCRAFT

Boeing B 737-800 aircraft VT-JGA (MSN 30410) was manufactured in year October 2002. On the day of accident, the aircraft had logged 37630:18 airframe hours and 27791 cycles and was holding a valid certificate of airworthiness and flight release prior to flight. The Jet Airways was having valid Air Operator Permit (AOP).

The aircraft and engines were being maintained under continuous maintenance as per approved maintenance program consisting of calendar period based maintenance and flying hours /cycles based maintenance.

The last major inspection C6 Check was carried out on 28.11.2013 and aircraft had logged 4412:55 hours/ 3305 cycles after inspection. The last periodic inspection A2 Check was carried out on 09.03.2015 at Mumbai.

The load and trim sheet was prepared before flight and C.G. of the aircraft was within the operating limits. There was no sang reported on the aircraft prior to the accident flight.

The involved LH Aft Trunnion Pin was overhauled at ST Aerospace Solutions (Europe) A/S, Oslo, Norway. The Pin was overhauled on March 2012 and installed along with Landing Gear on 30-04-2012 by Jet Airways at Delhi. The Pin has logged

1. TSN /CSN 37126 hrs / 27429 cyc
2. TSO/CSO 8895 hrs/6724 cyc

M/s ST Aerospace Solutions (Europe) A/S, Oslo was approved by FAA and EASA but not approved under CAR -145 by DGCA. As per DGCA CAR M Sub part B Para MA.201 Rev1 dated 15th February 2015 page 22 para (g) "*Maintenance of large aircraft, aircraft used for commercial air transport and components thereof shall be carried out by a CAR -145 approved maintenance organization*".

However, as per DGCA CAR M Sub part E Para MA.501 Rev1 dated 15th February 2015 page 48 para 5 *"For the purpose of CAR - M, a document equivalent to a CA Form 1 may be:*

- *a release document issued by an organisation under the terms of a bilateral agreement signed by DGCA*
- *EASA Form ONE*
- *FAA Form 8130-3*
- *Any other form acceptable to DGCA.*"

The landing Gear overhauled by M/s ST Aerospace, Oslo was issued with EASA Form -1.

2.2 WEATHER :

At the time 0700 UTC, the visibility of 6000 meters, temperature 30 degree, dew point 17 and QNH 1014 Hpa/29.96" Hg, winds 070/02kts.Clouds Scattered at 2500 ft (750 m) and Broken at 1000ft (3000m).

2.3 OVERHAUL OF TRUNNION PIN BY M/s ST AEROSPACE SOLUTIONS (EUROPE) A/S, OSLO, NORWAY AND FAILURE INVESTIGATION.

The LH landing Gear Trunnion Pin Sl. No. E2410 and RH landing Gear Trunnion Pin Sl. No. E2338 was overhauled on 27th March 2012 and issued with EASA Form -1. M/s ST Aerospace Solutions (Europe) A/S, Oslo was approved by FAA and EASA but not approved by DGCA , India under CAR -145.The overhaul process sheets of Trunnion Pin were send to NTSB and it was found that the appropriate procedures as outlined for the landing gear overhaul were carried out. Both the left and right pins were apparently processed at the same time. As per Jet Airways Quality Department Manual Chapter 2 credentials of the proposed vendor was evaluated through a desktop audit of documents supplied. However, the manual doesn't restrict to Jet Airways to carryout work at DGCA CAR-145 approved organization.

After the accident, the failure investigation of Trunnion Pin were carried out at DGCA & NTSB, USA. The report reveals that that the "the LH trunnion pin has failed in fatigue originating from black strip which is probably a pre-existed crack". "Chicken wire" cracking was observed over the entire chrome surface of the pin. The fractured aft trunnion pin contained an intergranular crack on the fracture face measuring 0.018 inch from the outer diameter (OD). Fatigue cracking was observed emanating 0.22 inch from the intergranular crack. Fracture initiation occurred by heat induced cracking which propagated during processing by a hydrogen embrittlement mechanism. Once in service, fatigue cracking initiated off of the existing crack until final fracture by ductile separation.

2.4 PASSENGER EVACUATION

Passengers and crew were evacuated through L1 & L2 escape slides. However, both side over-wing exits windows and R1 & R2 doors were operated. The passengers carried their hand baggage and not removed the shoes during evacuation. Also, passengers were evacuated to the left side where the engine was touching ground. The R1 door the slide got inflated and detached from the aircraft as girt bar was not properly engaged in the locks. The crew at R1 door received minor injury during evacuation. There was no instruction from the cockpit crew regarding side for evacuation nor did cabin crew access external conditions before commencing evacuation. The cabin crews were not able to handle the passengers effectively as numbers of passengers were observed sliding downs the escape slides with their cabin baggage's, which is not as per the procedure. The left L1 & L2 slides were used by cabin crew for evacuation even though there was hydraulic leak on LH landing gear & LH Engine touching the runway. Later, the aircraft side floor fittings and deflated slide was engaged on R1 door for condition & engagement, found satisfactory. Circumstantial evidence indicates that the slide may not have been engaged properly at the time of departure. Post flight medical Examination of Cockpit Crew & Cabin Crew were

not carried out after the accident even though same is mandatory as per Jet Airways Flight Safety Manual.

2.5 CORELATION BETWEEN CVR, DFDR & ATC TAPE

The data from CVR, DFDR and ATC tape was analysed and following are the salient findings

1. The landing was carried out by PIC and co-pilot was doing the duties of monitoring the instruments.
2. ILS landing was carried out on R/W 19.At 07:48:50 UTC Landing Gear was lowered at 07:48:50 at Rad. Alt 1751 ft and Flap handle was moved to 40 at 07:49:11.
3. Aircraft landed on Runway at 07:51:15 with Normal Accn. 1.65 G, CAS 121 Knots (V ref is 124kts & Khajuraho airport runway elevation is 728 feet)
4. During Landing roll at 07:51:28, with ground speed 36 knots, LH Landing gear collapsed. Aircraft Roll changes from 0.88 to -5.27. (Aircraft Rolled to left as engine touching the ground).
5. At 07:51:29 Engine Reverser 2 and 1 stowed, LH Gear UP Indication.
6. PIC informed ATC about left main gear collapse. ATC confirmed the crew about left hand side landing gear collapse. Also, informed crew about some smoke coming out at landing Gear area.
7. PIC informed ATC that they are carrying out evacuation on the runway and requested ATC to send all emergency services to the aircraft.
8. The flight crew carried out Evacuation checklist and advised cabin crew to evacuate.
9. At 07:53:16, the DFDR recording stopped. However, there was ATC communication between PIC & ATC.

2.6 CIRCUMSTANCES LEADING TO THE ACCIDENT:

M/s Jet Airways B-737-800 aircraft VT-JGA flight 9W- 2423 (Delhi -Varanasi-Khajuraho – Delhi) was involved in an accident at Khajuraho Airport on 13.4.2015 at 0751 UTC (1321 IST).PIC carried out ILS landing and maximum G load recorded during landing was 1.65 G. During landing Roll, 15 seconds after touchdown, at speed 36 knots left main landing gear aft trunnion pin broke and aircraft started deviating to the left of center line. The aircraft came to stop on runway with damage to the LH landing gear and resting on LH engine, Nose & RH landing Gear. Hydraulic fluid spillage occurred due to damage to LH main landing gear. Emergency evacuation was carried out on the runway. All four main doors escape slides & four emergency over wing windows were opened. However, the passengers used two escape slides (L1 & L2) for evacuation. One cabin crew received minor injuries (bruises) during evacuation. Passengers carried their hand baggage and not removed the shoes during evacuation and there was no instruction from the cockpit crew regarding side for evacuation nor did cabin crew access external conditions before commencing evacuation. After the accident, the failure investigation

of Trunnion Pin was carried out at DGCA & NTSB, USA. The report reveals that that the LH trunnion pin has failed in fatigue originating from black strip which is probably a pre-existed crack. Chicken wire cracking was observed over the entire chrome surface of the pin. Fracture initiation occurred by heat induced cracking which propagated during processing by a hydrogen embrittlement mechanism. Once in service, fatigue cracking initiated off of the existing crack until final fracture by ductile separation.

3. CONCLUSIONS:

3.1 FINDINGS:

a) The Certificate of Airworthiness and the Certificate of Registration of the aircraft was current/valid on the date of accident.
b) The certificate of flight release was valid on the day of accident.
c) Both the pilots were appropriately qualified to operate the flight.
d) Prior to the accident flight the aircraft had operated Bengaluru-Delhi- Varanasi and there was no snag reported on the aircraft.
e) The weather at the time of landing at Khajuraho was fine and is not a contributory factor.
f) The enroute flight was uneventful and the aircraft landed safely at Khajuraho as per filed flight plan.
g) PIC carried out ILS approach and landing on R/W 19 at Khajuraho Airport and the maximum G load recorded during landing was 1.65 G.
h) During landing Roll, 15 seconds after touchdown at speed 36 knots left main landing gear aft trunnion pin broke
i) After 40 second from touchdown, aircraft came to stop on runway with damage to the LH landing gear and resting on LH engine, Nose & RH landing Gear. Hydraulic fluid spillage occurred due to damage to LH main landing gear.
j) Emergency evacuation was carried out on the runway. All four main door escape slides & four emergency over wing windows were opened. However, the passengers used two escape slides (L1 & L2) for evacuation. One cabin crew R1 received minor injuries (bruises) during evacuation.
k) There was no fire nor any fire extinguishing material used. The runway was closed after the accident as aircraft became disable on the runway. Due to closure of runway one A-320 aircraft VT-ESE of Air India stuck at Khajuraho Airport which had landed before 9W-2423. The Jet airways aircraft was removed from runway at 1115 UTC on 16-04-2015 and airport opened for normal operation.
l) The left L1 & L2 slides were used by cabin crew for evacuation even though there was LH Engine touching the runway and smoke at landing gear area as informed by ATC. Also, the LH over wing exit was opened. The cabin crew was not able to handle the passenger effectively as number of passengers sliding downs the escape slides with their cabin baggage's and shoes.

m) Post flight medical Examination of Cockpit Crew & Cabin Crew were not carried out after the accident even though same is mandatory as per Jet Airways Flight Safety Manual.

n) The Landing Gear was overhauled along with Trunnion Pin by M/s ST Aerospace Solutions (Europe) A/S, Oslo in March 2012 and installed on VT-JGA in April 2012.

o) M/s ST Aerospace Solutions (Europe) A/S, Oslo was approved by FAA and EASA but not approved under CAR -145 by DGCA, India.

p) As per Jet Airways Quality Department Manual Chapter 2 credentials of the proposed vendor was evaluated through a desktop audit of documents supplied. However, the manual doesn't restrict to Jet Airways to carryout work at DGCA CAR-145 approved organization.

q) After the accident, the failure investigation of Trunnion Pin were carried out at DGCA & NTSB, USA. The report reveals that that the "the LH trunnion pin has failed in fatigue originating from black strip which is probably a pre-existed crack". "Chicken wire" cracking was observed over the entire chrome surface of the pin. Fracture initiation occurred by heat induced cracking which propagated during processing by a hydrogen embrittlement mechanism. Once in service, fatigue cracking initiated off of the existing crack until final fracture by ductile separation.

r) Another Jet Airways Boeing 737-900, registration VT-JGD while performing scheduled domestic passenger flight 9W-354 from Delhi to Mumbai on 03-03-2016 was involved in an accident at Chhatrapati Shivaji International (CSI) Airport, Mumbai when the RH Landing Gear Aft Trunnion Pin Broke during Landing Roll. The Landing Gear was overhauled by M/s ST Aerospace Solutions (Europe) A/S, Oslo in July 2013. The accident is under investigation.

3.2 PROBABLE CAUSE OF THE ACCIDENT:

The LH Aft landing Gear trunnion pin failed due to overload following fatigue growth. Crack initiation was in the heat affected area where excessive grinding was done at the time of overhaul. Initial crack growth is charterized by intergranular cracking (assisted by hydrogen embrittlement mechanism) until fatigue took over.

4. SAFETY RECOMMENDATIONS:

4.1 JET AIRWAYS

i. M/s Jet Airways to review its evacuation procedures.

4.2 DGCA

i. DGCA may carry out Safety Audit of Maintenance Department of Jet Airways.
ii. DGCA may review the CAR M regulations regarding maintenance / overhaul of aircraft and its components thereof at Foreign Organizations not approved by DGCA.
iii. DGCA may issue necessary circular to all Scheduled airlines highlighting proper passenger evacuation procedure during such accidents.

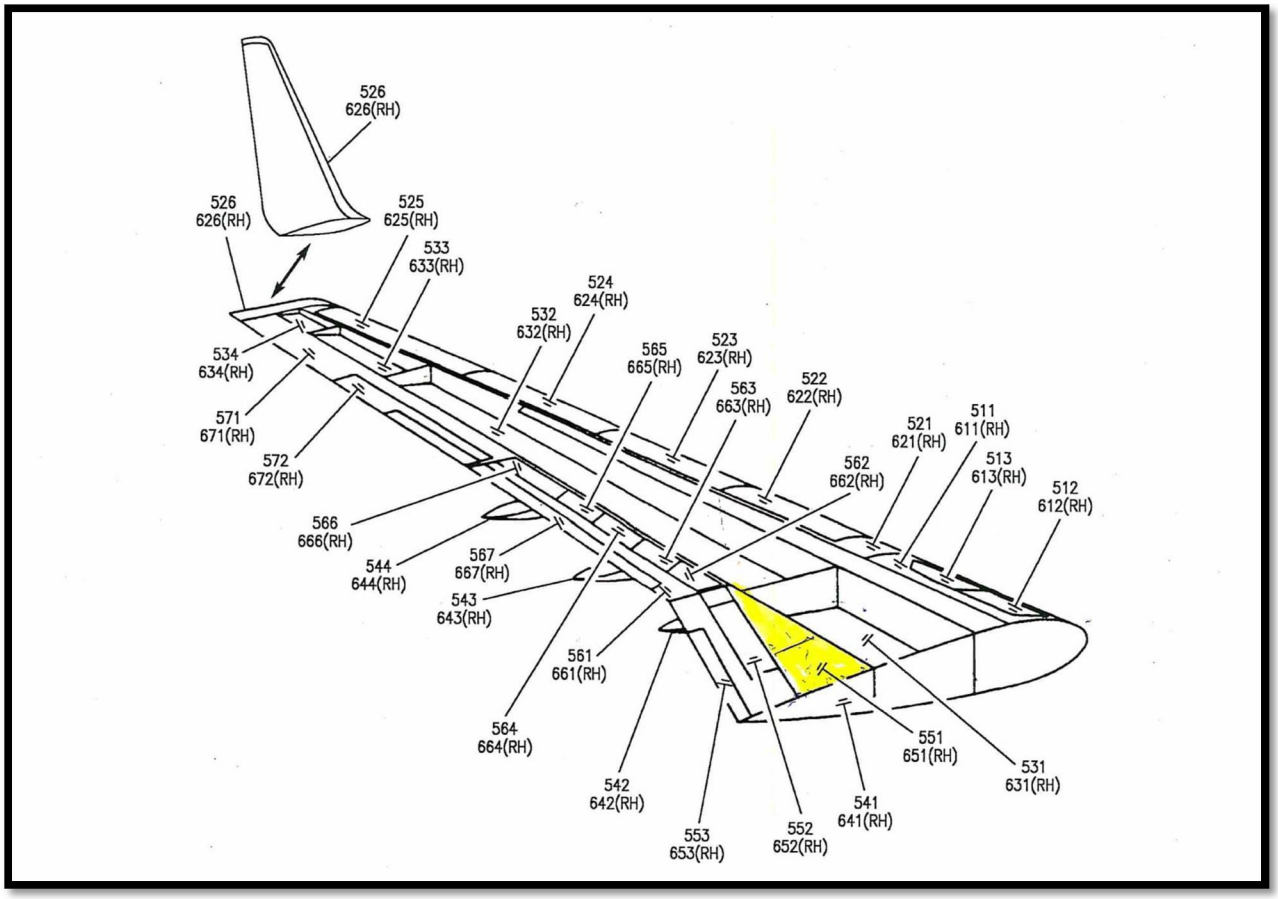
(Manoj Kumar)
Dy. General Manager, Air India
Member

(Capt. Rajiv Yadav)
Air India, (Former FOI, DGCA)
Member

(Amit Gupta)
Deputy Director, AED
DGCA

Date: 8th June 2017
Place: New Delhi


Aircraft resting
on Engine #01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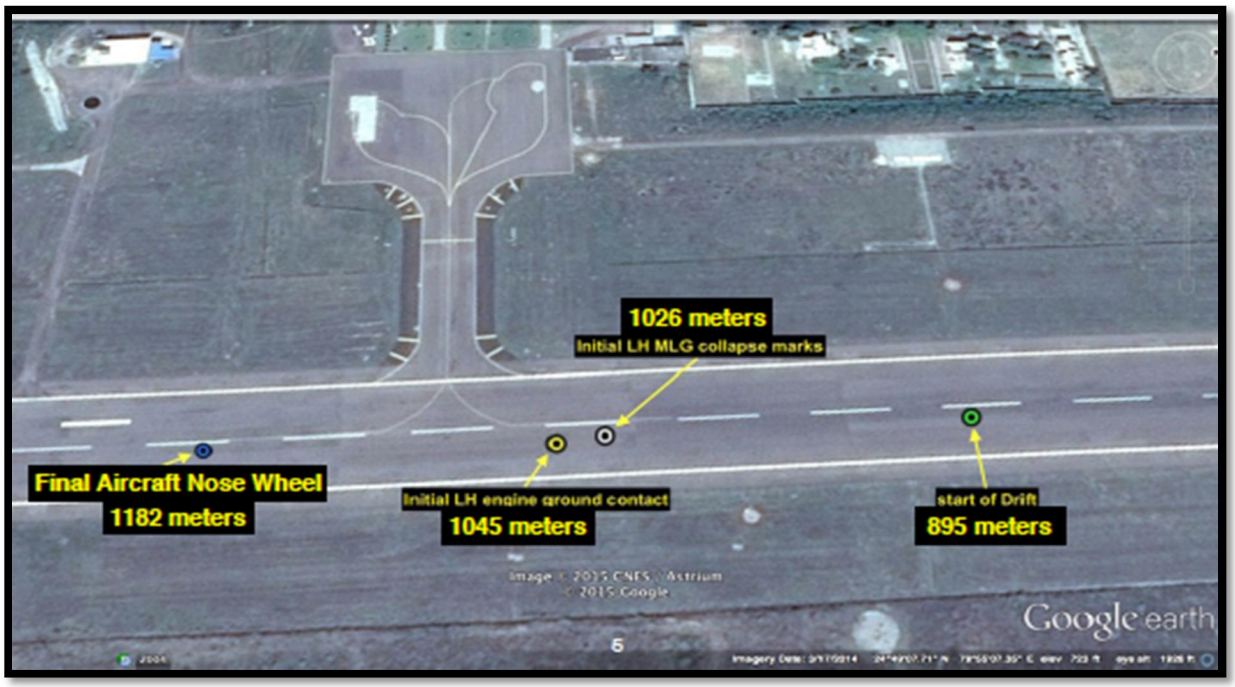
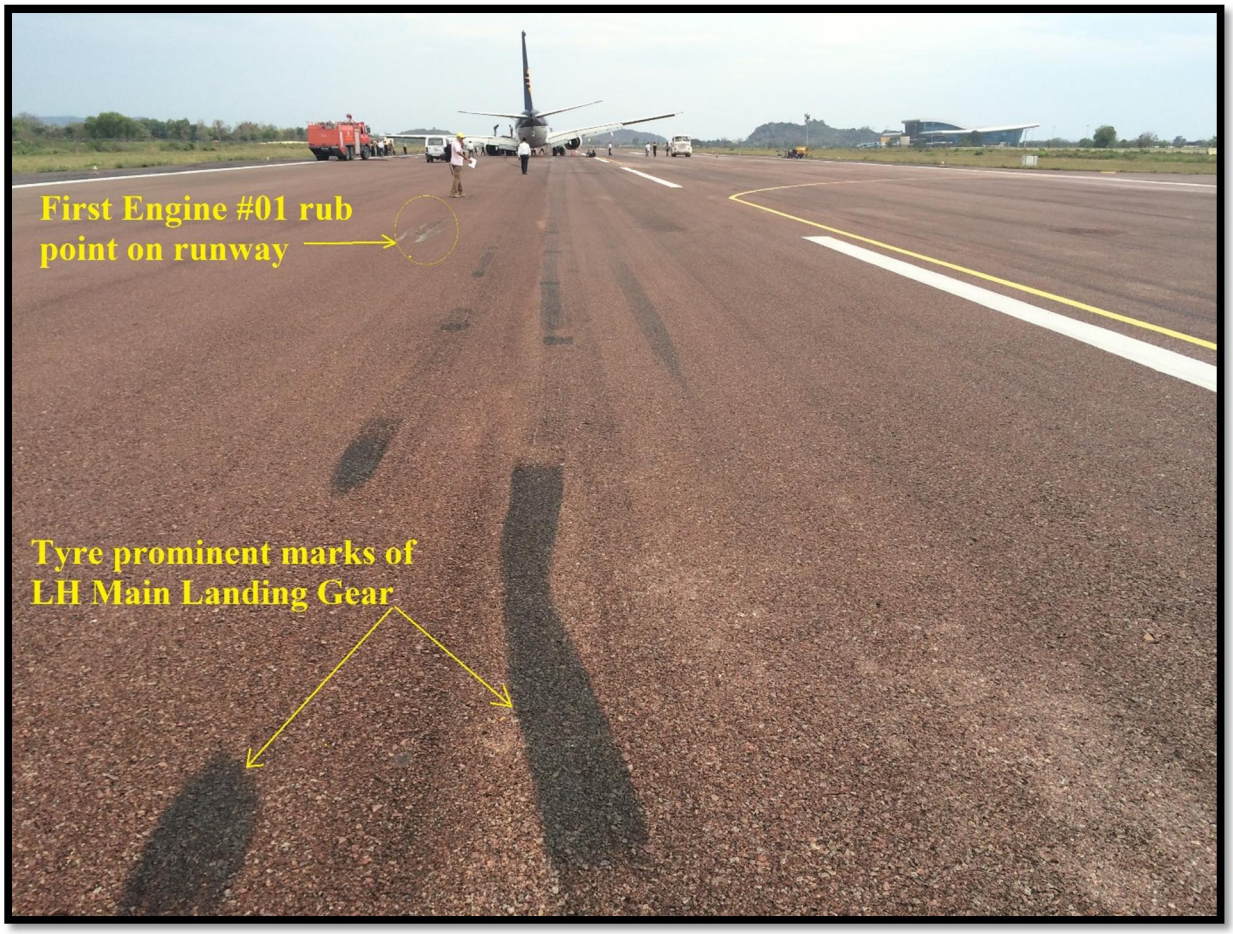
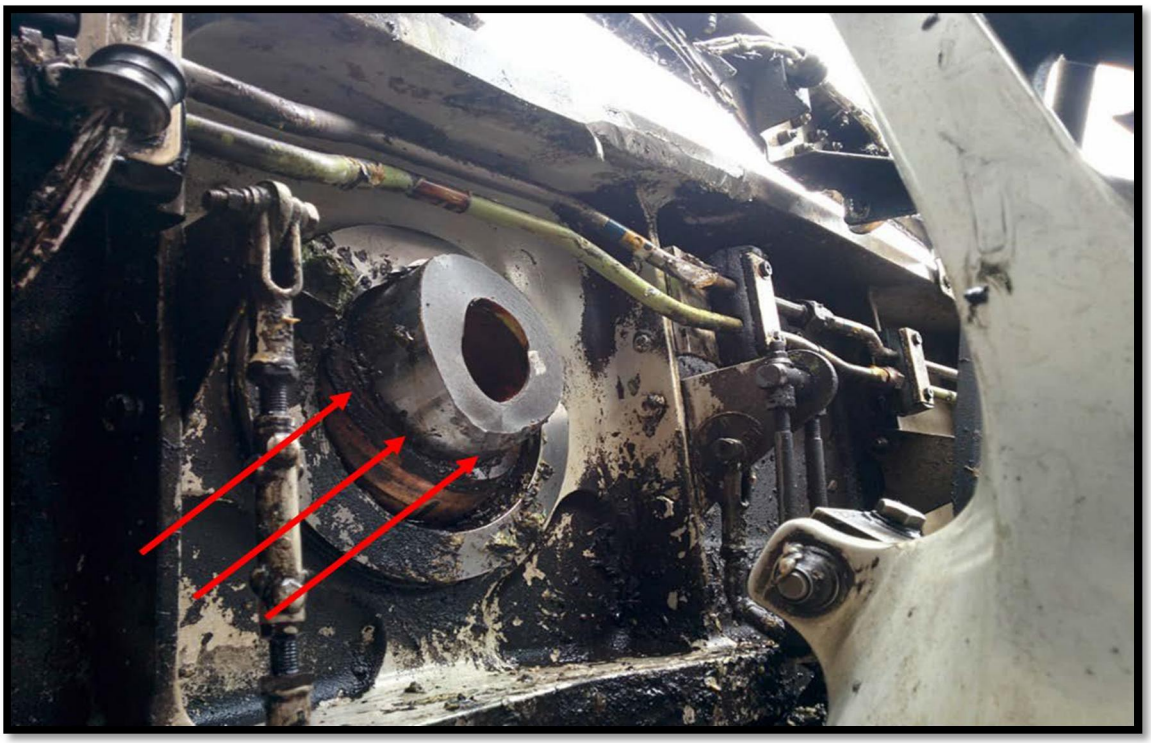
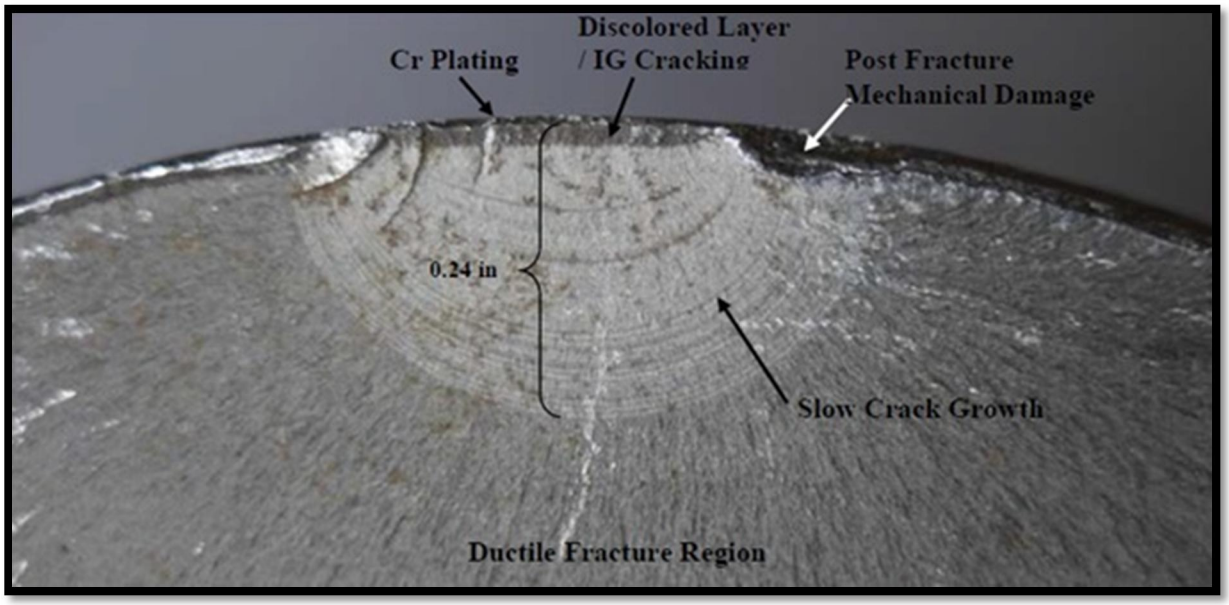
Fuel Tank
Fuel Tank
LANDING GEAR
BELOW THIS
PANEL


konnect


1026 meters
Initial LH MLG collapse marks
Final Aircraft Nose Wheel
1182 meters
Initial LH engine ground contact
1045 meters
start of Drift
895 meters
Image © 2015 CNES / Astrium
© 2015 Google
Google earth


First Engine #01 rub
point on runway
Tyre prominent marks of
LH Main Landing Gear




Discolored Layer
Cr Plating
/ IG Cracking
Post Fracture
Mechanical Damage
0.24 in
Slow Crack Growth
Ductile Fracture Region