Final Investigation Report on Accident to M/s Jet Airways (India) Ltd. B-737-900 Aircraft VT-JGD on 03-03-2016 at Mumbai Airport

COMMITTEE OF INQUIRY VT-JGD

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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) LTD., BOEING B 737-900 AIRCRAFT VT-JGD AT MUMBAI AIRPORT ON 03-03-2016

1.	Aircraft	Type	Boeing 737-900
		Nationality	Indian
		Registration	VT-JGD
2.	Owner		Washington Lease Co. Ltd., Man Island
3.	Operator		M/s Jet Airways (India) Ltd., Mumbai
4.	Pilot – in –Command		ALTP Holder
	Extent of injuries		NIL
5.	Co Pilot		CPL Holder
	Extent of injuries		NIL
6.	Date & Time of Accident		03-03-2016; 1622 UTC
7.	Place of Accident		Taxiway N9, CSI Airport, Mumbai
8.	Last point of Departure		IGI Airport, New Delhi
9.	Intended landing place		CSI Airport, Mumbai
10.	No. of Persons on board		120 (Passengers)+ 06 (Cabin Crew)
	Extent of injuries		NIL
11.	Type of Operation		Scheduled Passenger Flight
12.	Phase of Operation		During landing Roll
13.	Type of Accident		RH landing Gear collapsed due failure of Aft landing gear Trunnion Pin
14.	Co-ordinates of Accident Site		Lat 19° 5′ 19″ N , Long 72° 52′ 5″ E AMSL 37 feet

(All timings in the report is in UTC)

SUMMARY:

Jet Airways Boeing 737-900, VT-JGD while operating scheduled domestic passenger flight 9W-354 from Delhi to Mumbai with 120 passengers and 8 crew on 03-03-2016 was involved in an accident at Chhatrapati Shivaji International (CSI) Airport, Mumbai. The aircraft had safely landed on runway 27 at 16:22 UTC and was about to vacate the runway via taxiway N9 when the right main landing gear collapsed. The aircraft could not vacate the runway and became disabled on taxiway N9 with tail portion projecting on runway 27. Runway 09/27 was closed for flight operations while the aircraft was being removed. All air traffic used runway 14/32. The recovery work was completed by 0530 UTC on 04-03-2016 and the aircraft was towed to hanger.

As per DFDR the "G" load during landing was 1.44 G. After 16 sec from touch down during landing roll, at 58 Kts, there was right roll of 4.57° and the aircraft veered to the right with a noise which felt like a tire burst to the cockpit crew. To maintain directional control first officer moved the tiller. The aircraft vacated by N9 taxiway and after vacation the aircraft stopped on its own on the taxiway with the tail of the aircraft not fully clear of runway 27. Flaps was moved to 40, in case if the situation warranted an evacuation. PIC contacted on VHF 2 to dispatch / maintrol of Jet Airways and the FO was monitoring VHF 1. Sequentially, APU was started and Engine No. 2 was shut down and later No. 1 engine. PIC advised the cabin crew not to DISARM the doors until advised. On arrival of passenger stairs at 1651 UTC, passengers safely disembarked through the L1 door and no emergency evacuation was carried out.

As per ATC, sparks were observed from Right side landing gear when aircraft was moving on Runway 27 between Taxiway N 7 and N 8. ATC informed crew, Fire Station and Apron control. At 1627 UTC, the CFT sprayed foam type fire Extinguisher on the RH Engine area and also on spilled Hydraulic Fluid to prevent fire.

Ministry of Civil Aviation vide order No. AV 15029/3/2016-DG 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 as Chairman and Sh. Raje Bhatnagar, Assistant Director of Airworthiness, Ms. Shilpy Satiya, Air Safety Officer and Sh. Dinesh Kumar Air Safety Officer as members.

The Committee of inquiry determined the cause of accident as "The RH Aft landing Gear trunnion pin failed due to base metal heat damage as a result of abusive grinding of the chrome plate that likely occurred during the last overhaul".

FACTUAL INFORMATION

1.1 History of Flight

On 03.03.2017, M/s Jet Airways Boeing 737-900, VT-JGD while operating a scheduled domestic passenger flight 9W-354 from Delhi to Mumbai with 120 passengers and 8 crew was involved in an accident at Chhatrapati Shivaji International (CSI) Airport, Mumbai. The aircraft landed safely on runway 27 at 16:22 UTC and was about to vacate the runway via taxiway N9 when the right main landing gear collapsed. There were no injuries to any person onboard the aircraft. The aircraft sustained substantial damage.

Before the accident flight on 03.03.2017, the aircraft had successfully operated 04 flights (Delhi- Mumbai, Mumbai-Delhi, Delhi-Mumbai and Mumbai-Delhi). The accident flight (Delhi- Mumbai) was the 05^{th} flight of the day. The flight Delhi- Mumbai chocks off at 1415 UTC and aircraft took off at 1428 UTC from IGI Airport, Delhi. The flight was uneventful till landing at Mumbai.

The landing was carried out by co-pilot and PIC was carrying out Supervised Line Flying (SLF). Both the crew was cleared by M/s Jet Airways to carry out SLF duties. During landing flare, aircraft floated a little and the touchdown was normal.

The aircraft landed with the "G" load of 1.44. After 16 seconds from touch down during landing roll, at around 58 Kts, there was right roll of 4.57° and the aircraft started veering to the right with a noise which felt like a tire burst to the cockpit crew. To maintain directional control first officer moved the tiller. The aircraft vacated by N9 taxiway and after vacation the aircraft stopped on its own on the taxiway with the tail of the aircraft not fully clear of runway 27. The taxiway N 9 is about 2600 meters/8550 feet down the runway 27. Flaps were moved to 40, in case if the situation warranted an evacuation. Thereafter, PIC contacted to dispatch / maintrol of Jet Airways on VHF 2 and the F/O was monitoring VHF 1. Sequentially, APU was started and Engine No. 2 was shut down and later No. 1 engine was also shut down. PIC advised the cabin crew not to DISARM the doors until advised.

As per ATC, sparks were observed from Right side landing gear when aircraft was moving on Runway 27 between Taxiway N 7 and N 8. The same was informed to Crew, Fire Station and Apron control. Also, ATC pressed the crash bell and immediately fire tenders preceded to the crash site. Fire Tenders observed that the Aircraft had bogged down on Taxiway N-9. There was hydraulic leakage and starboard side engine had almost touched the ground. There was no sign fire or smoke observed on accident aircraft, same was informed to the ATC. Fire tenders carried out foam carpeting to mitigate the risk due to spillage. On arrival of passenger stairs, passengers were safely disembarked through the L1 door and no emergency evacuation was carried.

Runway 09/27 was closed for flight operations while the aircraft was being removed, all other air traffic used runway 14/32. The recovery work was completed by 0530 UTC on 04-03-2016 and the aircraft was towed to hanger.

1.2 Injuries to person

Injuries	**Crew**	**Passengers**	**Others**
Fatal	NIL	NIL	NIL
Serious	NIL	NIL	NIL
Minor	NIL	NIL	NIL
None	2+6	120	NIL

1.3 Damage to aircraft

The aircraft sustained substantial damages. During landing roll, the RH landing gear collapsed and aircraft was resting on its nose and left Main Landing Gear (MLG) and right engine pod. Following main damages occurred to the aircraft.

a) RH MLG partially separated from Airframe.
b) Both RH MLG doors and attachment found bend and cracked.
c) Aft end of RH MLG punctured the composite panel above the wing surface.
d) Hanger link mount dislocated and assembly found adrift.
e) RH MLG beam scrapped & gouged along forward upper & lower edges at 03 locations.
f) RH MLG beam Aft Trunnion bearing race assembly, Pin assembly, cross bolt damaged and trunnion pin sheared.

g) All RH upper fixed trailing edge panels attachment rods& brackets bent and torn.

h) RH lower fixed trailing edge panel, attachment rods & bracket No. 115A27110 damaged.

i) RH MLG beam attachment fitting scratched on lower end.

j) RH inboard flap track #5 transmission unit and attachment fitting damaged.

k) RH outboard MLG beam support fitting and idler link support assembly damaged.

l) RH inboard Trailing edge flap torque tube and fairleads bent and damaged.

m) RH engine inlet cowls, fan cowls scrapped along the lower surface.

n) RH engine thrust reversers severely scrapped along lower surface and latches found damaged.

o) Hydraulic fluid spillage occurred on Taxiway N9 due to damage to RH MLG.

1.4 Other damage: NIL

1.5 Personnel information:

1.5.1 Pilot – in – Command:

Age/ date of Birth	40 Yrs / 10.06.1975
Sex	Male
Licence Type	ATPL
Date of Issue	24/01/2001
Type endorsements	Multi Engine Land
Aircraft Rating	B 737-700/800/900/400
Date of Joining Jet Airways	25/08/2000
Instrument Rating validity	24/01/2021
FRTOL validity	20/07/2017
RTR	23/12/2017
Date of Medical Examination & validity	23/10/2015 valid 22/04/2016
Date of Last Line/Route Check & validity	08/02/2016 valid 07/02/2017
Date of last Proficiency& IR Check	04/02/2016 & 05/08/2015
Date of last English language	28/02/2017

Proficiency	
Date of Last CRM Training / Validity	18/06/2015/ valid up to 17/06/2016
Date of last Monsoon Training	18/06/2015/ valid up to 17/06/2016
Date of last Simulator Refresher / Test	04/02/2016
Date of Refresher & validity	18/06/2015 & 17/06/2016
Date of AVSEC & validity	21/06/14 & 20/06/2016
Date of SEP training & validity	18/06/2015 &17/06/2016
Total flying Experience on all types	14200:20 hrs
Total Experience on Type: PIC	9330:00 hrs
Total Experience on Type: Co-Pilot	4870:20 hrs
For Last 1 Year	966:23 hrs
Total in last 90 days	242:40 hrs
For Last 30 days	31:19 hrs
For Last 7 days	17:38 hrs
For the last 24 hrs	05:12 hrs
Rest Period Prior to duty Flight	17:01 hrs
Check Pilot Rating	04/08/2011

1.5.2 Co-Pilot (PF)

Age / Date of Birth	40 years/ 22-10-1975
Sex	Male
License	CPL
Validity	22-07-2016
Type Endorsements	Multi Engine Land
Aircraft Rating	Cessna 152 A (PIC), Boeing 737-700/800/900 (Co-Pilot)
Date of Joining Jet Airways	03-07-2006
Instrument Rating Validity	22-07-2016
FRTOL Validity	23-03-2019
RTR Validity	12-06-2035
Date of Medical Examination & Validity	04-06-2015 & 03-06-2016

Date of Last Line / Route Check & Validity	21-01-2016 & 20-01-2017
Date of Last Proficiency / IR Check	23-11-2015
Date of Last English Language Proficiency	11-03-2015
Date of Last CRM Training	09-12-2015
Date of Last Monsoon Training	21-10-2015
Date of Last Simulator Refresher / Test	23-11-2015
Date of Refresher & Validity	23-10-2015 & 22-10-2016
Date of AVSEC & Validity	29-03-2014 & 28-03-2016
Date of SEP Training & Validity	24-10-2015
Familiarity with Route / Airport flown for the last 12 months	YES
Total Flying Experience on All Types	6178:18 hrs
Total Experience on Type: Co-Pilot	5903:18 hrs
For Last 1 Year	319:41 hrs
Total in Last 90 Days	31:25 hrs
For Last 30 Days	25:21 hrs
For Last 7 Days	08:39 hrs
For the Last 24 Hours	04:03 hrs
Rest Period Prior to Duty Flight	18:14 hrs
Check Pilot / Examiner approval date (if applicable)	N/A

As per the records submitted by Jet Airways, Co-Pilot was cleared for supervised take-off and landing first time on 15/10/2007 and the last renewal was on 02/03/2016. During this period he has carried out 395 (three hundred and ninety five) assisted take off and 397 (three hundred ninety seven) number of assisted landings.

1.5.3. Cain Crew In charge (CCIC)

CCIC Crew Seat Location		Forward L1 Jump Seat
Date of Birth		07 June 1989
Date of Joining Jet Airways		13 December 2007
Date of Initial Training on Jet Airways		31-01-2008 to 18-03-2008
SEP initial training		12-03-2009
Date of Initial Practical Training	Wet Drill	29-02-2008
	Escape Slide Drill	05-03-2008
	Fire Drill	07-03-2008
Total Experience on B 737 aircraft as DGCA Approved Cabin Crew Member		08 Years
Rest availed prior to duty flight		15 hours.

1.6 Aircraft Information

1.6.1 General Description:

Boeing 737-900 is a Twin engine aircraft fitted with CFM 56-7B Engines 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 42.10 meters, wingspan is 34.32 meters and height of this aircraft is 12.6 meters. This airplane is certificated in the Transport Category, FAR Part 25 and Part 36.

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 were installed on the aircraft.

The aircraft was certified for 189 passenger's seat. However, VT-JGD was configured to 28 Business class seat and 138 economy-class passenger's seat (total 166 passenger).

1.6.2 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 overhaul life of 21000 Flight Cycle/ 10 year and life limit of Trunnion Pin is 75000 Flight Cycle. Greasing method of landing Gear is through Grease Gun. Landing Gear lubrication interval is 560 cyc or 90 days.

RH Trunnion Pin Details (as on 03.03.2016).

1. The pin was first installed on VT-JGC on 06-05-2003.
2. Pin was overhauled on 11-07-2013 and was again installed on VT-JGD on 06-08-2013.

TSN : 36963 Hrs
TSO/TSI : 7747 Hrs
CSN : 21914 Cycles
CSO/CSI : 4664 Cycles

The Landing Gear maintenance details of VT-JGD are as given below:

- Aircraft completed 04 sectors on the date of accident i.e. Delhi- Mumbai (02) and Mumbai-Delhi (02). The accident flight was 05 flight of the day i.e. Delhi-Mumbai.
- Last Extended Transit inspection done on 02-03-2016 at Delhi.
- Last 30 days inspection and Layover done on 02-03-2016 at Delhi.
- Last A4 check done on 31-01-2016 at Mumbai.
- Last C check done on 18-07-2015 at Mumbai.
- All 03 Landing Gear Servicing were carried out on 02-07-2015.
- Landing gears (LH, RH, and NOSE) lubrication carried out on 17-02-2016 at Delhi.
- Aft & Forward LH & RH MLG Trunnion Pin assemblies lubrication carried out on 10-02-2016 at Ahmedabad.
- Trunnion Pin Inspection of VT-JGD post Khajuraho Accident were carried out on 15-04-2015 at Delhi.

1.6.3 Aircraft Technical Information

Name of Operator	Jet Airways
Aircraft Type	B737-900
Registration Marking & S.No.	VT-JGD, MSN : 33740
Model	B737-95R
Date of Manufacture	22 July 2003
Date of Arrival in India	06 October 2003
Hours and Cycle at Arrival in India	32:32 Hours & 16 Cycles
Date of Induction in Jet Airways	10 October 2003

Validity of Certificate of Airworthiness	Unlimited.
C of A Category	Normal
C of A Sub Division	Passenger/ Mail/Goods
ARC was valid	29.11.2016
Total Flying Hrs / Cycles since manufacture as on 3.3.2016	TSN: 36560:08 hrs CSN: 21426
The last major check/inspection carried out on the aircraft	Last C6 check done on 20.07.15
Total Flying Hrs/cycles/landing at Last major periodic inspection	TSI: 34496:20 Hours CSI: 20135
Last periodic inspection	A4 check done on 31.01.16. TSN :36259 Hours/21235 Cycles
Last layover inspection	Done on 02.03.16 TSN :36551:05 Hours/21421 Cycles
CVR & DFDR details	CVR P/N: 980-6022-001, S/N: 120-09698 DFDR P/N: 2100-4043-00, S/N: 000574357
SELCAL Code	JQ-HK
Mode S Transponder	1000 0000 0000 0000 1111 1110
Type of Engine	CFMI CFM56-7

Weight and Balance Information:

The Details of basic weight schedule were as follows:-

Aircraft Empty Weight	42703.85 Kgs
Max fuel capacity(At density of .785 kg/litre)	20315.41 Kgs
Maximum Takeoff weight	74389.00 Kgs
Empty weight CG (cm)	1658.63 cm
Datum (from forward of front spar)	540 inches
Maximum Permissible number of Passengers	LOPA:166 (C28-Y138), TCDS: 189
Minimum number of flight Crew required	2 Pilots, 5 cabin attendant

Weight	Actual Weights for Flight on 03-03-2016 in Kgs	Maximum Permissible weight in Kgs
Take-off Weight	65817	74389
Landing Weight	60842	66814
Zero fuel Weight	55181	63639

During the first flight of the day on 03-03-2016, Pilot raised following snags after landing at Mumbai.

1. A/C seems to shimmy at certain taxi speed.
2. On Ldg sel A/c oscillation observed in cruise.
3. Yaw damper lt. came on approach and got reset.

Maintenance were carried by AME at Mumbai on 03-03-2016 after the first flight.

a) As per work order W/O 2646330:- Nose L/G insp. No abnormalities found. No leak and Tyre condition good. Nose wheel TPG C/N observed 205 psi which is normal. A/c normalized. Crew to report further.
b) As per work order W/O 2775166:- for snag 2 & 3 MEL 22-3-2 applied. Same invoked. Crew briefed. Cockpit placarded. DDPG complied. MEL is CAT 'C'. Expiries on 13-03-2016.

No defueling was carried out at Mumbai after the accident on 03-03-2016.

As per Pilot Defect Report raised after accident, "*After landing between 80-60 knots approx., we heard a thud and aircraft started turning towards right. While vacating runway we felt aircraft suddenly tilted towards the right hydraulic system 'A' was lost. NNC carried out.*"

1.7 Meteorological information:

The weather at Chhatrapati Shivaji International Airport (CSIA), Mumbai on 03/03/2016 is as under. The time of accident was 1622 UTC.

Time in UTC	**Wind Direct-ion**	**Speed (KT)**	**Vis (m)**	**Weather**	**Clouds**	**Temp (°)**	**Dew Point**	**QNH hPa**	**Remark**
1500	080	08	3000	FU	Few AC 100	33	16	1013	NOSIG
1530	340	07	3000	FU	Few AC 100	32	15.0	1013	NOSIG
1600	230	07	3000	FU	Few AC 100	32	15.0	1013	NOSIG
1630	020	03	3000	FU	Few AC 100	32	15.0	1013	NOSIG
1700	300	06	3000	FU	NSC	31	15.0	1014	NOSIG

1.8 Aids to navigation:

Mumbai airport is equipped with VOR (frequency 116.60 MHz), DME (frequency 1200/1137 MHz), NDB (frequencies 396 kHz), ASDE (frequency 9375 MHz). PAPI & ILS Cat- II is installed on Runway 27. PAPI & ILS Cat-I is installed at 09 & 14 and SALS is installed at Runway 32.

1.9 Communications:

At the time of accident the aircraft was in contact with Mumbai ATC on frequency118.1 MHz (TWR). From the tape transcript it was apparent that there was no communication problem between the Flight Crew & ATC.

The Communication frequencies for Tower are 118.1 MHz, Approach Mumbai Control (N) is 132.7 MHz, Approach Mumbai Control (S) is Approach Mumbai Control (N) is 132.7 MHz SMC Controller Mumbai Ground is 121.9 MHz / 121.85 /121.75 MHz, TAR/MSSR Radar 127.9 M Hz/119.3 MHz, Mumbai Radar (N) 132.7 MHz/ 120.5 MHz, Mumbai Radar (S) 125.35 MHz/ 120.5 MHz and ATIS Broadcast is at 126.4 M Hz.

Salient observations made from the tape transcript (between JAI 354 and ATC TWR) at are given below:

1. JAI contacted TWR.
2. TWR informed JAI about the winds and Rwy.
3. TWR cleared JAI to Land.
4. TWR advised JAI to vacate Via N8.
5. TWR advised another aircraft to Go around due runway not available.
6. JAI informed TWR that they are hanging on RWY and had Tyre Burst.
7. TWR advised JAI to contact SMC at 121.9 MHz.
8. JAI informed SMC that they are on N9 and not vacated RWY.
9. JAI informed SMC that all operations normal and aircraft had tilted and have tyre burst.

1.10 Aerodrome information.

Chhatrapati Shivaji International Airport (CSIA) is an international airport located in Mumbai, Maharashtra. The IATA location Identifier code is BOM and ICAO location Indicator code is VABB. The airport is operated by Mumbai International Airport Limited (MIAL), a Joint Venture between the Airports Authority of India (AAI) and a consortium led by GVK Industries Ltd. The elevation AMSL of airport is 11.9 m (39.1 ft).The airport is licensed by DGCA No. AL/Public /005 for both IFR and VFR traffic. The airport reference code is 4F. The airport has two cross runways made of Asphalt. The length of Runway is as under

- **Rwy 27--** 3448m × 60m
- **Rwy 09 --** 3188m × 60m
- **Rwy 14/32--** 2871m × 45m

The Airport Reference point is 19°05'30"N, 072°51'58"E. Runway has marking for Designation, THR, TDZ, centre line, Rwy Edge and is lighted for THR, Edge, End, TDZ, and centre line. The Airport Rescue and Fire Fighting Services was Category '9' (Nine).

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. 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	Honeywell, USA	980-6022-001	120-09698	02 Hrs 05 min
2	DFDR	L3 Communication, USA	2100-4043-00	000574357	121 hrs 40 mins

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 co-pilot (PF) and PIC 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 27 and aircraft landed on Runway R/W 27.
5. PIC informed ATC that they had not cleared the Runway 27 & suspected tyre burst.
6. ATC informed crew to contact ATC (Ground) at 121.9 MHz
7. PIC requested ATC (Ground) to send jeep to check what was happened as there is quite tilt of the aircraft.
8. ATC (Ground) send follow me jeep to N9 to inspect the aircraft. Follow me jeep informed ATC that Aircraft Right outer wheel deflated and aircraft had caught fire earlier.
9. ATC (Ground) informed pilot to switch off both engines.
10. ATC (Ground) informed crew about spark.
11. Follow me again informed ATC (Ground) that the tires are OK and there is some problem with the under carriage. Hydraulic oil is leaking and aircraft has sink down to the right side.
12. PIC informed CCIC that they had a hydraulic leak, so aircraft is tilted now. Also, advised to be on seats, in case of any emergency.
13. PIC advised Maintrol to inform dispatch for doctors at the bay.
14. Co-pilot informed the passengers on PA to be clam and there was no danger. Also, informed that Step ladders are coming.
15. PIC informed CCIC to disarm L1 & R1 doors and deplane from L1 door.

1.11.2 Flight Data Recorder (FDR)

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

- Accident flight VIDP-VABB lasts from 14:17:58 to 17:26:41UTC.
- Total airtime for the flight from Delhi-Mumbai was 01:53:00 hrs (i.e. from 119:39:23 hrs T/O to 121:32:23 hrs T/D.)
- LDG SEL (Landing Gear) down at 16:19:27 UTC.

- At 1000 ft AFE (16:20:19 UTC), Flaps are 30, CAS is 151 and ROD is 788. Both A/P is at CMD position and A/T are active.
- At 500 ft AFE (16:20:57 UTC), Flaps are 30, CAS is 152, ROD is 893, A/P is at FD and A/T is active.
- At touch down (16:21:47 UTC), Flaps are 30, CAS is 141, ROD is 30, Vert. G is 1.44, Pitch 2.11 and Roll is -1.05, Heading 271.
- At 16:22:03, CAS is 58 knots and aircraft roll changes from -0.35 to 4.57, Heading 270.
- Hydraulic Qty., System A starts reducing and becomes 0 at 16:23:49 UTC.
- Hydraulic Oil Pressure Sys A, starts reducing drastically from 16:24:39 UTC.
- Ground Spoiler/SPD BRK 1 was activated from 16:21:46 to 16:22:33 UTC.
- Ground Spoiler/SPD BRK 2 was activated from 16:21:45 to 16:22:32 UTC.
- ENG REV 1 & 2 deployed at 16:21:51 and stowed back at 16:22:18 UTC.
- At 16:22:47 UTC, the aircraft speed reduced to 0, Heading 296.
- CUT OFF 2 (Engine 2) at 16:27:03 and CUT OFF 1 (Engine 1) at 16:28:35 UTC.
- WARN-MASTER (Master Caution Warning) from 16:22:16 to 16:22:23 and 16:25:12 to 16:25:46 UTC.
- There was no Fire Warning.
- The DFDR stop recording at 16:28:38 UTC.

1.12 Wreckage and impact information.

The aircraft touch down on RWY 27. After touch down at speed 60-80 Knots, the aircraft started deviating to the right of center line and came to halt with damage to the starboard landing gear and resting on RH engine, Nose & RH Landing Gear. Hydraulic fluid spillage occurred on the runway due to damage to starboard main landing gear.

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

1. Distance of aircraft from threshold to touch down on Rwy 27 :- 3130ft
2. Distance of aircraft from to Touch down point to full stop. :- 4030ft
3. Distance of aircraft from threshold to full stop on Rwy 27 :- 7160ft
4. Engine rub marks on Runway to stop point on TWY N9:- 560 meters.
5. Distance of aircraft nearest position to RWY centerline: - 37 meters.

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 Mumbai and were found negative. After the accident, Post flight medical Examination of Cockpit Crew were carried out at Mumbai Airport and were found negative.

1.14 Fire:

There was no pre or post impact fire. However, ATC observed sparks when engine contacted the runway 27 and informed the same to crew. FT-1 reached the site and carryout foam carpeting on RH engine side to mitigate the fire risk.

1.15 Survival aspects:

The accident was survivable. No emergency evacuation was carried out at Taxiway N9. Passengers were evacuated using passenger Step ladder through L1 door as the aircraft was tilted towards right. The first passenger disembark from aircraft at 1651 UTC and all passenger disembarked by 1702 UTC.

As per cabin crew statement, after accident a lady passenger seated at 12 C felt dizziness and claustrophobic & was shifted to seat 1D. Later PIC opened the cockpit sliding windows and instructed cabin crew to open L1 door for better ventilation.

1.16 Tests and research:

The failed RH aft landing Gear Trunnion pin of VT-JGD was examined in DGCA and NTSB, USA. Along with RH, LH aft landing Gear Trunnion pin of VT-JGD, all the other 08 pins overhauled by M/s ST Aerospace Oslo were also sent to NTSB, USA for detailed examination.

1.16.1 Failure Investigation by Failure Analysis Lab, DGCA

Failure Analysis Lab, DGCA carried out metrological analysis of failed trunnion pin of VT-JGD. The lab report reveals that the "*the trunnion pin has failed in fatigue originating from a pre-existing crack*".

1.16.2 Failure Investigation by NTSB, USA

The fractured trunnion pin was examined by Boeing Equipment Quality Analysis (EQA), Non- Destructive Inspection (NDI) and Boeing Research & Technology (BR&T) Metallurgical and Fracture Analysis.

The details of 10 Trunnion overhauled by ST Aerospace & sent to NTSB for investigation are as under:-

S. No.	PART NO.	SERIAL NO.	PIN LOCATION	INITIALLY INSTALLED DETAILS	PIN LAST OVERHAULED DATE	INSTALLED ON DETAILS		REMOVAL DETAILS			
						Date	A/C REGN	TSN	TSO	CSN	CSO
1	161A1192-4	90827-0891	LH MLG AFT	06-05-2003	11-07-2013	06-08-2013	VT-JGD	36,963	7,747	21,914	4,664
2	161A1192-4	E2430	RH MLG AFT	06-05-2003	11-07-2013	06-08-2013	VT-JGD	36,963	7,747	21,914	4,664
3	161A1188-4	MF64-016	LH MLG FWD	11-12-2002	12-07-2013	06-08-2013	VT-JGD	37,054	7,747	22,528	4,664
4	161A1188-4	MF64-003	RH MLG FWD	11-12-2002	11-07-2013	06-08-2013	VT-JGD	37,054	7,747	22,528	4,664
5	162A0302-2	E1471	RH PIN NLG	03-Oct-2003	25-09-2013	15-12-2013	VT-JNL	36,162	7,349	22,185	5,423
6	162A0301-2	E1474	LH PIN NLG	03-10-2003	18-09-2013	15-12-2013	VT-JNL	36,162	7,349	22,185	5,423
7	162A0301-2	E1496	LH PIN NLG	06-05-2003	26-07-2013	27-04-2014	VT-JGC	34,880	5,664	20,679	3,429
8	162A0302-2	0069-9T788	RH PIN NLG	06-05-2003	19-08-2013	27-04-2014	VT-JGC	34,880	5,664	20,679	3,429
9	161A1188-4	K010904-006	LH MLG FWD	22-11-2004	25-09-2013	27-12-2013	VT-JGC	36,148	6,707	17,648	4,061
10	161A1188-4	K10903-039	RH MLG FWD	22-11-2004	26-09-2013	27-12-2013	VT-JGC	36,148	6,707	17,648	4,061

- The Pin at S. No. 2 installed on VT-JGD broke during landing on 03-03-2016.
- The Nose L/G Trunnion Pin (LH & RH) of VT-JGM couldn't be sent to NTSB as the aircraft was deregistered .

As per the BR&T report, the Barkhausen inspection results indicated that the fractured RH MLG aft trunnion pin (S/N E2430) and the LH MLG aft trunnion pin (S/N 90827-0891), both from aircraft of VT-JGD, and the LH forward trunnion pin (S/N K010904- 006) from aircraft VT-JGC showed indications of possible base metal heat damage. All three pins were analyzed by BR&T Metallurgy / Fracture Analysis. The analysis results of fractured RH MLG Pin of VT-JGD are as follows:

Fractured RH MLG aft trunnion pin (S/N E2430) of VT-JGD

1. Fracture initiation was due to base metal heat damage as a result of abusive grinding of the chrome plate that likely occurred during the last overhaul.

2. The fracture originated in an area of un-tempered martinsite (UTM) on the outer diameter of the trunnion pin. The crack originated from intergranular separation, a result of hydrogen embrittlement during cadmium plate processing. The crack propagated by Trans-granular fatigue mode with ductile separation at final fracture. Multiple cracks were found near the fracture origin.
3. The material met the material specification heat treat requirements.

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 104 aircraft, which includes 10 Boeing 777-300 ER aircraft, 08 Airbus A330-200 aircraft, 68 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 CAR 145 approval & has approx. 13900 employees in the organization.

1.18 Additional information:

1.18.1 Accident to M/s Jet Airways B 737-800 aircraft VT-JGA at Khajuraho on 13/04/2015

M/s Jet Airways B 737-800 aircraft VT-JGA involved in a similar at Khajuraho while operating a schedule flight 9W- 2423 from Varanasi to Khajuraho. While landing, left main landing gear collapsed due to failure of Aft Main Landing Gear Trunnion Pin. After the accident the damaged LH MLG Aft Trunnion Pin and RH MLG Trunnion Pin were sent to NTSB for failure analysis. Based on Preliminary report from NTSB, M/s Jet Airways informed that only two set of Landing Gears installed on (VT-JGA, VT-JGC) were overhauled by ST Aerospace Oslo. As a precautionary measure, after the accident of VT-JGA, on 20-08-2015, LH & RH aft trunnion pin of VT-JGC were removed from the aircraft.

After the accident of VT-JGD, M/s Jet Airways informed that the Landing Gear Trunnion Pin installed on VT- JGD was also overhauled by M/s ST Aerospace, Oslo.

On 14-04-2016, M/s Jet Airways informed that 03 set of landing Gear installed on (VT-JGA, VT-JGC, VT-JGD) were overhauled by ST Aerospace, Oslo along with 02 set of Nose landing Gear Trunnion Pin installed on (VT-JGM and VT-JNL). After the accident of VT-JGD, M/s Boeing advised Jet Airways to remove all the trunnion pins (Aft, front & Nose landing Gear) overhauled from ST Aerospace, Oslo and Send to NTSB for failure analysis. However, the Landing Gears overhauled by ST Aerospace were not removed.

1.18.2 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- JGD was involved in 03 incidents of landing above 2.1 G after overhauled trunnion pins were installed (6th August 2013).

Date	Severity level	Reg No	Flight number	Value (G)
28-01-2014	High	VT-JGD	JAI540	2.34
10-06-2014	High	VT-JGD	JAI301	2.16
09-02-2016	High	VT-JGD	JAI411	2.27

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

1.18.3 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

There was no inspection on Trunnion Pin after the Heavy Landing.

1.18.4. DGCA CAR M Regulation

As per old 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 new DGCA revised CAR M Issue 2 Rev 1 dated 23rd June 2017 page 24 para GM MA 201, wherein the Maintenance by CAR 145 organisation is required.

Also, CAR M Issue 2 dated 20 January 2017 page 110 AMC MA 613 (a) "component certificate release to service ", Para 2.8 *these alleviated requirements are based on the fact that credit can be taken for their technical capabilities and DGCA oversight.*

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*."

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*.

The Jet Airways Continued Airworthiness Management Exposition (CAME) Part 1.2 (Aircraft Maintenance Program) includes Maintenance, Repair, and Overhaul etc. Jet Airways CAR M and CAME Part 1.2.5 and 1.2.6 permits installation of components with FAA 8130/EASA Form 1/ CA Form1. CAME & CAR- M is also approved by DAW, Mumbai.

Jet Airways is maintaining Aircraft, Engine and APU at CAR -145 approved organization. Whereas, Landing Gear was maintained at an agency which was not approved under CAR 145 and this agency was issuing documents acceptable under CAR-M, which is contradictory to CAR 145 . The accident gear of VT- JGD was overhauled as per CMM in ST Aerospace, Norway. The landing Gear was received with EASA Form 1, which is acceptable as per CAR M, but this is in contradiction to CAR 145.

1.18.5 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 Jet Airways to carryout work at DGCA CAR-145 approved organization.

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

The installed Main Landing Gears Aft Trunnion Pins of VT-JGD were overhauled by M/s ST Aerospace Solutions (Europe) A/S, Oslo, Norway. The LH landing Gear Trunnion Pin Sl. No. 90827-0891 and RH landing Gear Trunnion Pin Sl. No. E2430 was overhauled on 11-07-2013. 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 06-08-2013 by Jet Airways.

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. Magna Flux Inspection
8. Shot Peening
9. Chrome Plating
10. Machining
11. Heat Treatment
12. Magna Flux Inspection
13. Cadmium treatment
14. Magna Flux Inspection
15. Chrome Treatment
16. Primer & Paint.

The overhaul process sheets of Trunnion Pin were checked and 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.

1.18.7 Component Data Management by M/s Jet Airways

M/s Jet Airways is using Aviation Maintenance Management Software (AMOS) for maintaining the details of aircraft components developed by Swiss Aviation Software (Swiss-AS), Switzerland. AMOS is a comprehensive, fully-integrated software package that successfully manages the maintenance, engineering and logistics requirements of modern airlines and MRO providers by fulfilling demanding airworthiness standards.

After the accident of VT-JGD, DGCA had issued show cause notice to Head of Logistics M/s Jet Airways that the parts sent to M/s ST Aerospace Solutions were not updated. In reply M/s Jet Airways informed that the landing Gear of VT-JGD came under exchange order and the staff while extracting the data from AMOS inadvertently extracted incomplete data. The logistic department had provided the landing Gear data only for Repair & return from M/s ST Aerospace Solutions. The logistic department informed the Quality Control that only Landing Gears of VT-JGC were serviced by M/s ST Aerospace Solutions. The Quality Control only recommended to remove the Aft Trunnion Pin of LH & RH MLG on VT-JGC after the accident of VT-JGA. The Quality Control / Technical Services department did not verify /double checked the data on AMOS software provided by the Logistics.

1.18.8 Passenger Evacuation.

No emergency passenger evacuation were carried out after the accident. For disembarkation, passengers used Step ladder through L1 door as the aircraft was tilted towards right. The first passenger disembark from aircraft at 1651 UTC and all passenger disembarked by 1702 UTC. The time of accident was 1622 UTC. The foam fire extinguisher were used by FT-1 at 1627 UTC on the starboard side.

As per cabin crew statement, after accident a lady passenger seated at 12 C felt dizziness and claustrophobic & was shifted to seat 1D. Later PIC opened the cockpit sliding windows and instructed cabin crew to open L1 door for better ventilation.

1.19 Useful or effective investigation techniques*:* NIL

2. ANALYSIS

2.1 SERVICEABILITY OF THE AIRCRAFT

Boeing B 737-900 aircraft VT-JGD (MSN 33740) was manufactured in year July 2003. On the day of accident, the aircraft had logged 36560:08 airframe hours and 21426 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) & CAR-145 Approval.

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 Check 'C' Inspection was carried out on 18-07-2015 at Mumbai. AFT & Forward LH & RH Main Landing Gear (MLG) Trunnion Pin Inspection was carried out 10-02-2016 at Ahmedabad.

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 RH Aft Trunnion Pin was overhauled at M/s ST Aerospace Solutions (Europe) A/S, Oslo, Norway. The pin was first installed on VT-JGC on 06-05-2003. Pin was overhauled on 11-07-2013 and installed VT-JGD on 06-08-2013.The pin has logged

TSN / CSN : 36963 Hrs / 21914 Cycles

TSO / CSO : 7747 Hrs /4664 Cycles

After the present accident, all the Trunnion Pins overhauled by M/s ST Aerospace were removed from Jet Airways aircrafts and send to NTSB for failure analysis. However, all the Landing Gears overhauled by ST Aerospace were not removed.

Though, the aircraft was serviceable but the Trunnion Pin overhauled by the ST Aerospace were not removed after earlier accident due to error by Logistic Department in retrieving data from AMOS.

2.2 WEATHER :

As per MET report at1600 UTC, the visibility was of 3000 meters, temperature 32 degree, dew point 15 and QNH 1013 Hpa, winds 230/07kts. Few AC clouds at 10,000 feet. At the time 1630 UTC, the visibility was of 3000 meters, temperature 32 degree, dew point 15 and

QNH 1013 Hpa, winds 020/03kts. Few AC clouds at 10,000 feet. The time of accident was 1622 UTC. Therefore Weather is not a contributory factor to the accident.

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. 90827-0891 and RH landing Gear Trunnion Pin Sl. No. E2430 of VT-JGD was overhauled on 11/07/2013 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 any regulation. Both the left and right pins were apparently processed at the same time.

After the accident, all the Ten (10) Trunnion Pins overhauled by M/s ST Aerospace Solutions (Europe) A/S, Oslo were send for failure investigation NTSB, USA. Earlier also, two (02) Aft Trunnion pins of VT-JGA involved in accident at Khajuraho were also sent to NTSB for failure Investigation. Both Pins of VT-JGA and three (03) Pins (VT-JGD & VT-JGC) showed indications of possible base metal heat damage.

The Pins were overhauled at different time at by M/s ST Aerospace Solutions (Europe) A/S, Oslo

Both LH & RH aft trunnion pins of VT-JGA were overhauled on 27-03- 2012.

Both LH & RH aft trunnion pins of VT-JGD were overhauled on 11-07-2013.

LH forward main landing gear trunnion pin of VT-JGC was overhauled on 25-09-2013.

Fracture initiation of RH MLG Trunnion Pin of VT-JGD was due to base metal heat damage as a result of abusive grinding of the chrome plate that likely occurred during the last overhaul. The fracture originated in an area of un-tempered martinsite (UTM) on the outer diameter of the trunnion pin. The crack originated from intergranular separation, a result of hydrogen embrittlement during cadmium plate processing. The crack propagated by Trans-granular fatigue mode with ductile separation at final fracture. Multiple cracks were found near the fracture origin.

The LH MLG Trunnion Pin of VT-JGA had also failed in fatigue originating from black strip which was probably a pre-existing 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 of the existing crack until final fracture by ductile separation.

2.4. SELECTION OF M/s ST AEROSPSACE SOLUTIONS (EUROPE) A/S, OSLO and DGCA REGULATIONS

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

M/s ST Aerospace Solutions (Europe) A/S, Oslo was approved by FAA and EASA but not approved under CAR -145 by DGCA, India. DGCA CAR M Sub part E Para MA.501 permits acceptance of component with a release document issued by an organisation under the terms of a bilateral agreement signed by DGCA or EASA Form ONE or FAA Form 8130-3 or any other form acceptable to DGCA."

Also, CAR M Issue 2 dated 20 January 2017 page 110 AMC MA 613 (a) "component certificate release to service ", Para 2.8 these alleviated requirements are based on the fact that credit can *be taken for their technical capabilities and DGCA oversight.*

The Jet Airways Continued Airworthiness Management Exposition (CAME) Part 1.2 (Aircraft Maintenance Program) includes Maintenance, Repair, Overhaul etc. Jet Airways CAR M and CAME Part 1.2.5 and 1.2.6 permits installation of components with FAA 8130/EASA Form 1/ CA Form1. CAME & CAR- M is also approved by DAW, Mumbai.

Jet Airways is maintaining Aircraft, Engine & APU at CAR 145 approved organization but Landing Gear is not maintained at CAR 145 approved organization.

2.5 AMOS DATA MANAGEMENT

M/s Jet Airways is using Aviation Maintenance Management Software (AMOS) for maintaining the details of aircraft components. M/s Jet Airways informed that the landing Gear of VT-JGD came under exchange order and the staff while extracting the data from AMOS inadvertently extracted incomplete data. The logistic department had provided the

landing Gear data only for Repair & return from M/s ST Aerospace Solutions. The logistic department informed the Quality Control that only Landing Gears of VT-JGC were serviced by M/s ST Aerospace Solutions. The Quality Control only recommended to remove the Aft Trunnion Pin of LH & RH MLG on VT-JGC after the accident of VT-JGA. The Quality Control / Technical Services department not verified /double checked the data on AMOS software provided by the Logistics. However, the gear did not come under the exchange as it was earlier installed on VT-JGC and sent by Jet Airways for Overhaul to M/s ST Aerospace.

2.6 PASSENGER EVACUATION

No emergency passenger evacuation was carried using escape chutes after accident. The aircraft stopped at 1622 UTC whereas the first passenger disembark at Taxi bay N 9 from aircraft at 1651 UTC and all passenger disembarked by 1702 UTC using Step ladder through L1 door as the aircraft was tilted towards right. A lady passenger seated at 12 C felt dizziness and claustrophobic & was shifted to seat 1D. PIC opened the cockpit sliding windows and instructed cabin crew to open L1 door for better ventilation after accident.

2.6 CIRCUMSTANCES LEADING TO THE ACCIDENT:

M/s Jet Airways B-737-900 aircraft VT-JGD flight 9W- 354 (Delhi -Mumbai) was involved in an accident at Mumbai Airport on 03-03-2016 at 1622 UTC. The landing was carried out by Co-pilot & PIC was carrying out SLF. The aircraft landed safely on Runway 27 and during landing roll, 16 seconds after touchdown, at speed 58 knots Right main landing gear aft trunnion pin broke and Right Main Landing Gear collapsed. The aircraft started deviating to the right of center line. Pilot tried to vacate runway via taxiway N9 using tiller but aircraft stopped on taxiway. There was damage to the RH landing gear and aircraft was resting on RH engine, Nose & LH landing Gear. Hydraulic fluid spillage occurred due to damage to RH main landing gear. Maximum G load recorded during landing was 1.44 G. ATC observed sparks between Taxiway N 7 and N 8 when engine cowl was rubbing runway and informed Fire Station and Apron control. The CFT reached the aircraft and sprayed the foam fire Extinguisher on the No. 2 Engine & RH Landing gear area on spilled Hydraulic Fluid to prevent fire. The passengers disembarked from L1 door using passenger stairs.

After the accident, the failure investigation of Trunnion Pin was carried out at DGCA & NTSB, USA. The report reveals that that the RH trunnion pin failed due to base metal heat

damage as a result of abusive grinding of the chrome plate that likely occurred during the last overhaul. The fracture originated in an area of un-tempered martinsite (UTM) on the outer diameter of the trunnion pin. The crack originated from intergranular separation, a result of hydrogen embrittlement during cadmium plate processing. The crack propagated by Trans-granular fatigue mode with ductile separation at final fracture. Multiple cracks were found near the fracture origin.

3. CONCLUSIONS:

3.1 FINDINGS:

1) The Certificate of Airworthiness and the Certificate of Registration of the aircraft was current/valid on the date of accident.
2) The certificate of flight release was valid on the day of accident.
3) Both the pilots were appropriately qualified to operate the flight.
4) The landing was carried out by co-pilot and PIC was carrying out Supervised Line Flying (SLF).
5) The aircraft landed safely on Runway 27 at 1622 UTC and during landing roll, 16 seconds after touchdown, at speed 58 knots Right main landing gear aft trunnion pin broke and Right Main Landing Gear collapsed. Maximum G load recorded during landing was 1.44 G.
6) PIC tried to vacate runway via taxiway N9 using tiller but aircraft stopped on taxiway. There was damage to the RH landing gear and aircraft was resting on RH engine, Nose & LH landing Gear. Hydraulic fluid spillage occurred due to damage to RH main landing gear.
7) ATC observed sparks between Taxiway N 7 and N 8 when engine cowl was rubbing runway and informed Fire Station and Apron control. The CFT reached the accident site at 1627 UTC and sprayed the foam fire Extinguisher on the No. 2 Engine & RH Landing gear area on spilled Hydraulic Fluid to prevent fire.
8) All passengers disembarked from L1 door using passenger stairs at 1702 UTC.
9) After the accident, the failure investigation of Trunnion Pin was carried out at DGCA & NTSB, USA. The report reveals that that the RH trunnion pin failed

due to base metal heat damage as a result of abusive grinding of the chrome plate that likely occurred during the last overhaul.

10) Ten Trunnion pins overhauled by M/s ST Aerospace were sent to NTSB for failure investigation. Out of (10) ten pins, 02 others pins shows similar damages. Earlier two Aft Trunnion pins of VT-JGA, LH (broken) and RH overhauled by M/s ST Aerospace shows similar type of damages.

11) After the accident of VT-JGA, M/s Jet Airways informed that they had removed the LH & RH Aft Trunnion Pin of VT-JGC overhauled by M/s ST Aerospace as a precautionary measure.

12) However after the accident of VT-JGD, M/s Jet Airways informed that the landing Gear of VT-JGD came under exchange order and the staff while extracting the data from AMOS inadvertently extracted incomplete data.

13) The landing gear did not come under the exchange as it was earlier installed on VT-JGC and sent by Jet Airways for Overhaul to M/s ST Aerospace.

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

15) DGCA CAR M regulations doesn't restrict overhaul of Landing Gear at CAR 145 approved organization.

3.2 PROBABLE CAUSE OF THE ACCIDENT:

The Committee of inquiry determined the cause of accident as "The RH Aft landing Gear trunnion pin failed due to base metal heat damage as a result of abusive grinding of the chrome plate that likely occurred during the last overhaul".

4. SAFETY RECOMMENDATIONS:

4.1 JET AIRWAYS

i. In view lapse of AMOS entry, Jet Airways may review the AMOS system for corrective action.

4.2 DGCA

i. DGCA may review the CAR M regulations regarding maintenance / overhaul of aircraft and its components thereof at Foreign Maintenance & Repair Organizations (MRO) not approved by DGCA.

(Shilpy Satiya)
Air Safety Officer, AAIB
Member COI , VT-JGD

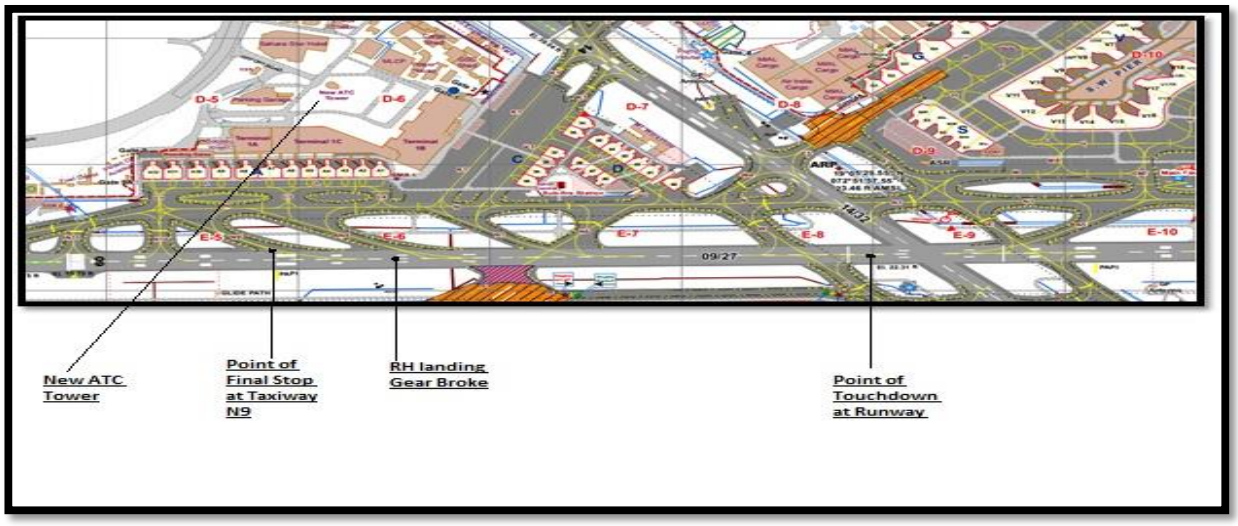
(Dinesh Kumar)
Air Safety Officer, AAIB
Member COI , VT-JGD

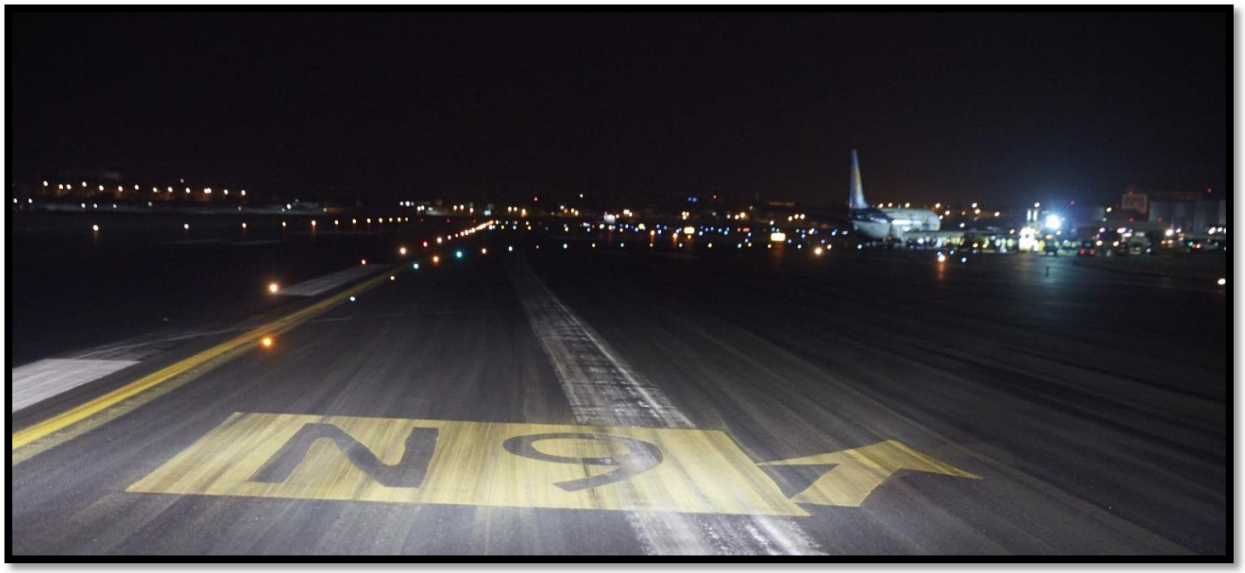
(Raje Bhatnagar)
Assistant Director Airworthiness, AAIB
Member COI , VT-JGD

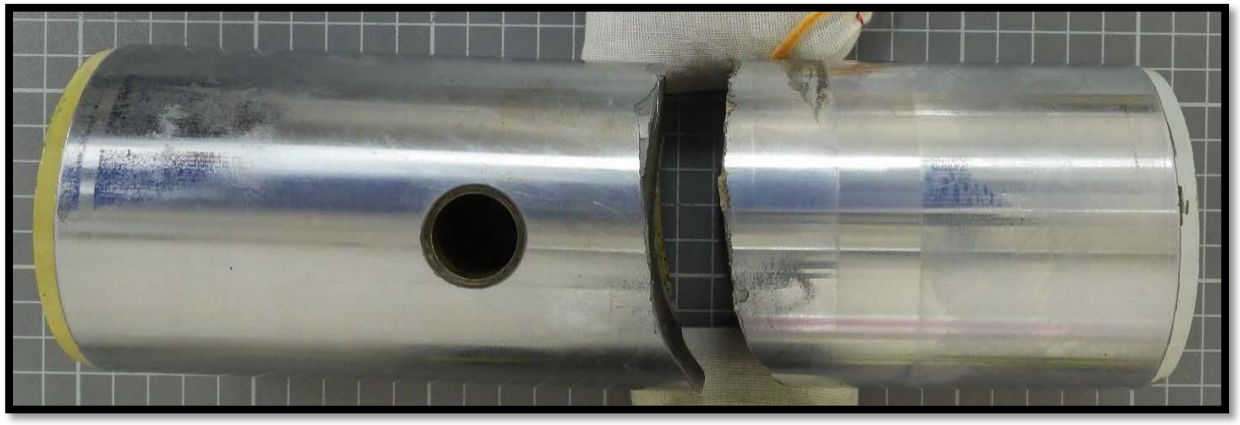
(Amit Gupta)
Deputy Director (AED),DGCA
Chairman COI , VT-JGD

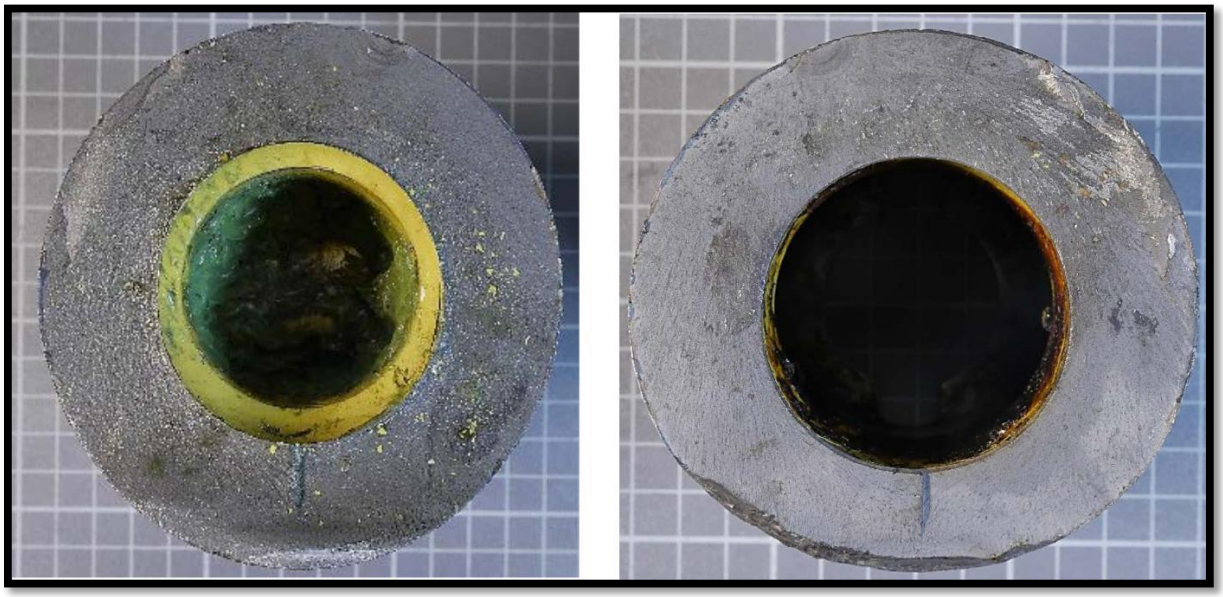
Date: 22-12-2017
Place: New Delhi

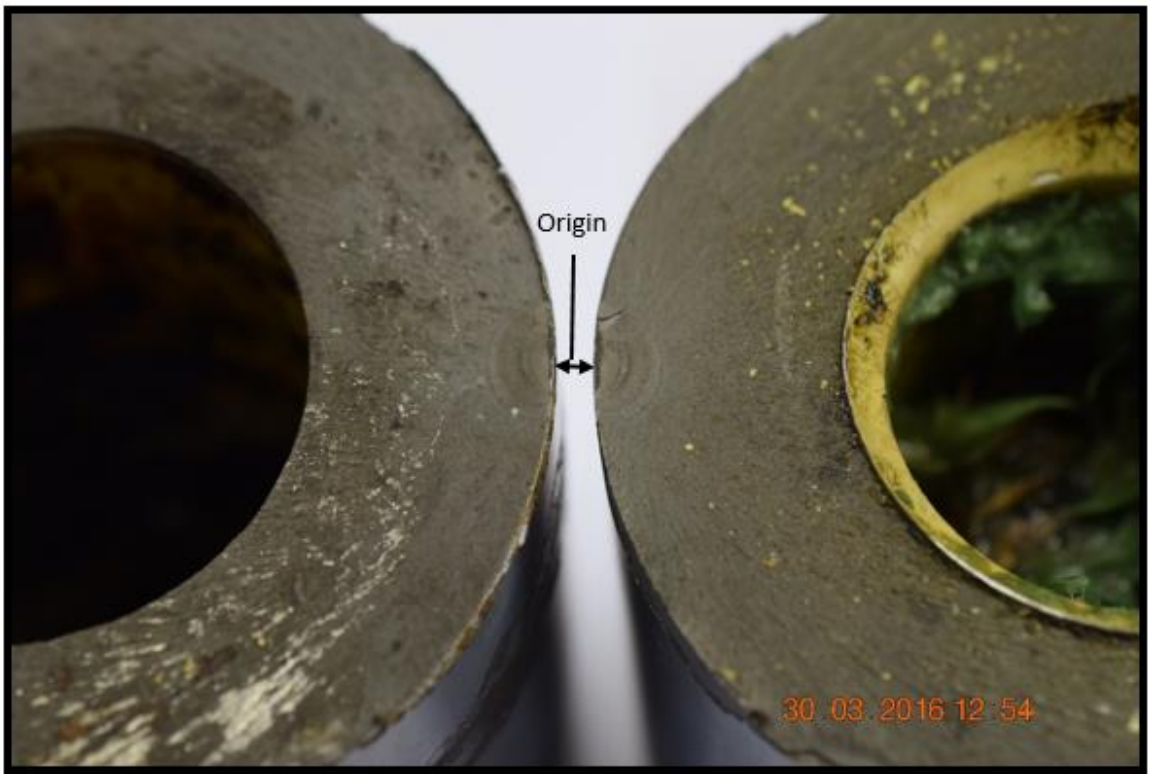
ACCIDENT PHOTOGRAPHS VT-JGD







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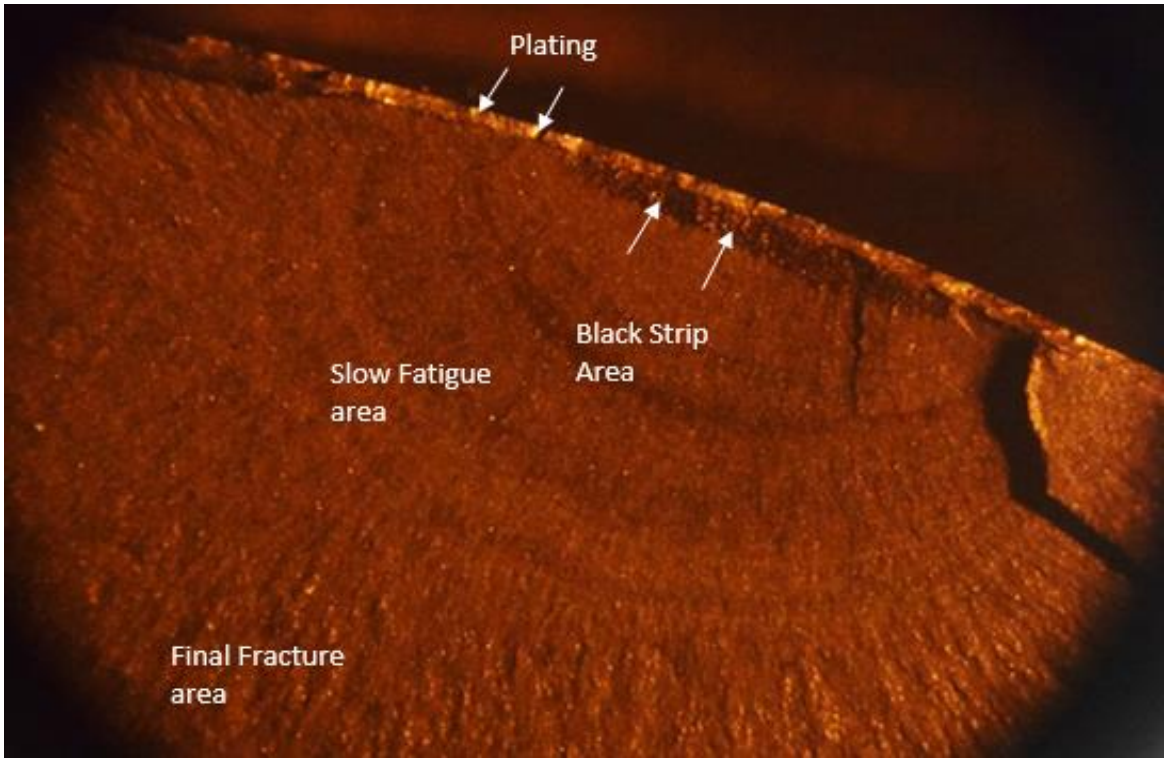
Plating
Black Strip
Area
Slow Fatigue
area
Final Fracture
area