AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

Reference:	CA18/2/3/8383

Aircraft Registration	**ZS-OEZ**	**Date of Accident**	07 November 2007	**Time of Accident**	1400Z	
Type of Aircraft	B737-200		**Type of Operation**	Scheduled Domestic		
Pilot-in-command Licence Type	Airline Transport	**Age**	50	**Licence Valid**	Yes	
Pilot-in-command Flying Experience	Total Flying Hours	13860		Hours on Type	3277	
Last point of departure	Cape Town International Aerodrome (FACT).					
Next point of intended landing	O.R. Tambo International Aerodrome (FAJS).					

Location of the accident site with reference to easily defined geographical points (GPS readings if possible)

On take-off Runway 01 at Cape Town International Aerodrome (FACT).

Meteorological Information	Wind 340/20; Temperature 16°C; Visibility 3000 m; Light Rain; Cloud 800 ft Overcast				
Number of people on board	2 + 4 + 106	**No. of people injured**	0	**No. of people killed**	0

Synopsis

During a take-off from Runway 01 at FACT, the right-hand engine separated from the wing. Following the engine separation, the aircraft continued to climb. The captain declared an emergency and his intention to land back on Runway 01. The aircraft was cleared for landing back on Runway 01 by ATC. The crew executed an uneventful single-engine approach and landed on Runway 01 at the aerodrome of departure.

The engine investigation revealed that the separation was as a result of the failed aft cone bolt, the outboard front cone bolt and the engine secondary support assembly. The aft secondary support was not recovered for examination. The abovementioned failures resulted in the engine separation from the right-hand wing.

All recovered failed components were subjected to a metallurgical analysis which revealed that the aft cone bolt had failed as the result of fatigue. The fatigue failure was attributed to the probability of incorrect installation (under-/over torque). The front outboard cone bolt and front engine support structure failed in overload as the engine swung forward and sideways during the sequence of the engine separation.

Probable Cause

Right-hand engine separated due to the failure of the aft cone bolt as the result of a pre-existing fatigue crack which was most likely caused by incorrect installation of the cone bolt.

IARC Date		Release Date	

AIRCRAFT INCIDENT REPORT

Name of Owner/Operator : Nationwide Airlines
Manufacturer : Boeing Aircraft Company
Model : B737-200
Nationality : South African
Registration Marks : ZS-OEZ
Place : Cape Town
Date : 07 November 2007
Time : 1400Z

All times given in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.

Purpose of the Investigation:

In terms of Regulation 12.03.1 of the Civil Aviation Regulations (1997) this report was compiled in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and ***not to establish legal liability****.*

Disclaimer:

This report is given without prejudice to the rights of the CAA, which are reserved.

1. FACTUAL INFORMATION

1.1 History of Flight

1.1.1 The aircraft was taking off from Cape Town International Airport (FACT), on a scheduled domestic flight from FACT to O.R. Tambo International Airport (FAJS). The flight deck crew reported that during take-off, when the aircraft was rotating, they noticed a sudden spool down indication on all right-hand engine gauges, followed by drastic attitude changes. The aircraft was banking towards the left and right side, then started to sink and thereafter yawed to the right. The right-hand engine thrust lever retarded uncommanded and the reverse thrust warning light also illuminated and remained on.

1.1.2 The crew managed to recover the aircraft from the uncommanded roll to both left and right and was able to establish a normal flight attitude. An emergency was declared on the radio frequency of 118.1MHz and the air traffic controller (ATC) was informed of their intention to turn back. The crew then started to read the aircraft engine-failure emergency procedure checklist whilst maintaining communication with ATC. Whilst the aircraft was in the circuit and returning back to FACT, the ATC alerted Rescue and Fire-Fighting Services. The emergency personnel then immediately dispatched to the runway to clear the runway of all hazardous debris.

1.1.3 The aircraft continued to climb and remained at an altitude of 3000 feet above mean sea level (AMSL), as it was vectored along the circuit by the ATC. The flight deck crew carried out one orbit with the aircraft prior to them receiving clearance to land on Runway 01. A safe landing on Runway 01 followed. The passengers were briefed

about the emergency situation and given the “brace command” shortly before touch-down.

1.1.4 The crew advised ATC that they were safely on the ground and vacated the runway at the taxiway before coming to a stop where the emergency response personnel were already awaiting the aircraft. The passengers were informed by the cabin crew to remain calm and seated while waiting for a step ladder vehicle to arrive. Whilst the step ladder vehicle was being driven into position, the captain walked into the cabin to check if there was anything that he could see through a window and was shocked to see that the right-hand engine had separated from the right-hand wing. The evacuation process of the passengers was conducted normally, without having to deploy the emergency escape slides. All the occupants disembarked the aircraft safely without any further incidents being reported.

1.1.5 The on-site investigation revealed that the forward engine mount support fitting (FEMS), of the right-hand engine had failed at the inboard engine attachment point. The outboard engine mount cone bolt had fractured at the shear section. The inboard cone bolt did not fracture but remained attached to the portion of the inboard FEMS fitting. It was also noted that the rear cone bolt had fractured at its shear section. The aft secondary support was not recovered from the accident scene.

1.2 Injuries to Persons

Injuries	Pilot	Crew	Pass.	Other
Fatal	-	-	-	-
Serious	-	-	-	-
Minor	-	-	-	-
None	2	4	106	-

1.3 Damage to Aircraft

The engine sustained substantial damage; however the wing structural integrity was not affected.

Photo 1: Showing the aircraft without the right-hand engine and parked on the taxiway.

1.4 Other Damage

1.4.1 There was no other damage caused during this accident.

1.5 Personnel Information

Captain:

Nationality	South African	Gender	Male	Age	50
Licence Number	**********	Licence Type	Airline Transport Pilot		
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Instrument				
Medical Expiry Date	30 April 2008				
Restrictions	Corrective lenses				
Previous Accidents	None				

Flying Experience:

Total Hours	13860
Total Past 90 Days	217
Total on Type Past 90 Days	192
Total on Type	3277

1.5.1 The Captain was employed by the operator from 01 November 1997 and resigned after three years, on 15 December 2000. The Captain was reappointed on 24 May 2006 and flew for the operator until the day of the accident. The last proficiency check of the Captain was done on 8 August 2007 and he was issued with a Certificate of Competency.

First Officer:

Nationality	South African	Gender	Male	Age	25
Licence Number	**********	Licence Type	Commercial		
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Tug; Instrument				
Medical Expiry Date	31 January 2008				
Restrictions	None				
Previous Accidents	None				

Flying Experience:

Total Hours	1007
Total Past 28 Days	28.9
Total on Type Past 28 Days	28.9
Total on Type	278.4

1.5.2 The First Officer joined the operator on 03 October 2007. A proficiency check was done to evaluate his competency on 17 October 2007 and he was issued with a Certificate of Competency. The aircraft type rating training of the Boeing 737-200 was

satisfactorily completed on 18 May 2007.

1.6 Aircraft Information

Airframe:

Type	Boeing 737-230A	
Serial No.	22118	
Manufacturer	Boeing	
Year of Manufacture	1981	
Total Airframe Hours (At time of accident)	57075.9	
Last "A" Check (Date & Hours)	25 July 2007	56852.5
Hours since Last "A" Inspection	223.4	
C of A (Issue Date)	04 October 1999; (Expiry 03 October 2008).	
C of R (Issue Date) (Present owner)	20 September 2006	
Operating Categories	Standard	

Left-hand Engine

Type	Pratt & Whitney
Model	JT8D-15; 15A
Serial No.	702866
Hours since New	39559.6
Hours since Overhaul	17324.6
Hours since Installation	3020

Right-hand Engine

Type	Pratt & Whitney
Model	JT8D-15; 15A
Serial No.	709022
Hours since New	43668.3
Hours since Overhaul	17324.6
Hours since Installation	3806

1.6 Meteorological Information

The following information was provided by the pilot:

Wind direction	340°	Wind speed	20 kts	Visibility	3000 m
Temperature	16°C	Cloud cover	OVC	Cloud base	700 ft
Dew point	*Not reported*				

Note: "Light rain" conditions were reported.

1.8 Aids to Navigation

1.8.1 The aircraft was equipped with standard navigational aids approved for this type of aircraft. According to the captain, the navigational aids were operating normally prior to the accident. All landing aids were serviceable at the time of the accident and the crew subsequently carried out an ILS approach before landing. The aircraft was monitored by ATC on the radar.

1.9 Communications

1. 9.1 Another aircraft witnessed the engine separation and advised the ATC accordingly. ATC confirmed that they were aware of it. However, ATC had by that time cleared another aircraft to land and cautioned the landing aircraft about rubble on the runway. Neither ATC, nor the landing aircraft opted to initiate a go-around. After landing, this aircraft confirmed that there was a lot of rubble in the centre of the runway.

1. 9.2 The crew declared an emergency to ATC on radio frequency 119.7 MHz and informed the ATC that they would be returning to the aerodrome. The ATC enquired from the accident aircraft whether the engine was "still there or is it gone" and the reply was "It is still there" but that they were also experiencing other problems, such as hydraulic problems.

1. 9.3 The Flight Deck Crew and Cabin Crew briefed the passengers about the emergency situation on the aircraft intercom and they were given the "brace command" shortly before touchdown.

1.10 Aerodrome Information

Aerodrome Location	Cape Town International Airport	
Aerodrome Co-ordinates	S33° 58' 05" E18° 36' 17"	
Aerodrome Elevation	151 feet	
Runway Designations	01/ 19	16/ 34
Runway Dimensions	3201m X 61m	1701m x 46m
Runway Used	01	
Runway Surface	Paved	
Approach Facilities	NDB, VOR, ILS	

1.10.1 No problems were reported relating to the aerodrome before the incident.

1.10.2 Emergency personnel were dispatched to ensure that the debris on the runway was cleared before the accident aircraft could land back on the runway. The time taken to clear the debris from the runway was fourteen minutes and nineteen seconds. During this period the runway could not be used.

Photo 2: Showing the emergency personnel clearing debris from the runway.

1.11 Flight Recorders

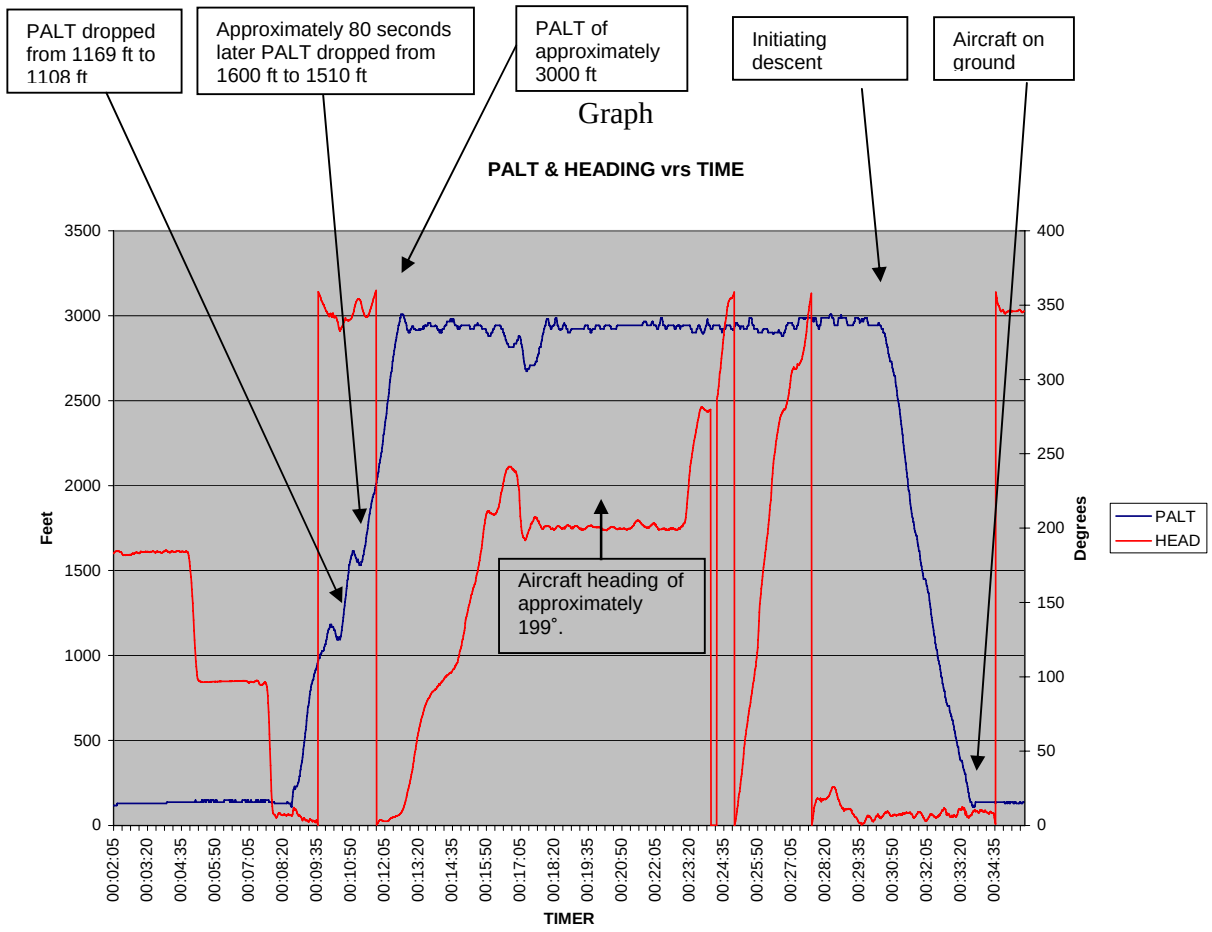
1.11.1 The aircraft was equipped with a flight data recorder (FDR) and cockpit voice recorder (CVR) as required by the Civil Aviation Regulations. The CVR was played back but did not contain any relevant information as it had been overwritten.

1.11.2 The relevant information of the FDR was downloaded and is shown in Graph-1 where:

The red line indicates the aircraft's heading and the blue line indicates the aircraft's pressure altitude (PALT) during taxiing and after take-off against minutes/seconds during taxiing, the flight and landing from Runway 01 at FACT.

(i) The red line (heading) shows the aircraft taxiing to Runway 01 and the heading after take-off, and shows the aircraft's heading of approximately 199˚ after the aircraft had climbed to a PALT of 3000 ft and eventually at 349˚ before landing back onto Runway 01.

(ii) The blue line (PALT) shows how the aircraft started its take-off roll and whilst climbing, the PALT dropped from 1169 ft to 1108 ft. Approximately 80 seconds later the PALT again dropped from 1600 ft to 1510 ft. The aircraft then continued to climb to a PALT of approximately 3000 ft and maintained this until descent.



Graph – 1

1.12 Wreckage and Impact Information

1.12.1 During the take-off and on rotation of the aircraft, the right-hand engine separated from the aircraft. The engine came to rest on the right-hand shoulder and short of the end of Runway 01. The accessory gearbox section made impact with the ground first at the six o'clock position and sustained the most damage. The fan Inlet Case was found further ahead.

1.12.2 The engine debris which was on the runway was cleared prior to the aircraft returning for the emergency landing. As a result, the exact location and position of the debris could not be determined during the on-site investigation.

Photo 3: Position of the engine and engine inlet casing.

1.12.4 The forward engine mount support fitting (FEMS) failed at the inboard engine attachment point. The outboard engine mount cone bolt fractured at the shearing area and failed, while the inboard cone bolt did not fracture but remained attached to the failed inboard portion of the FEMS fitting.

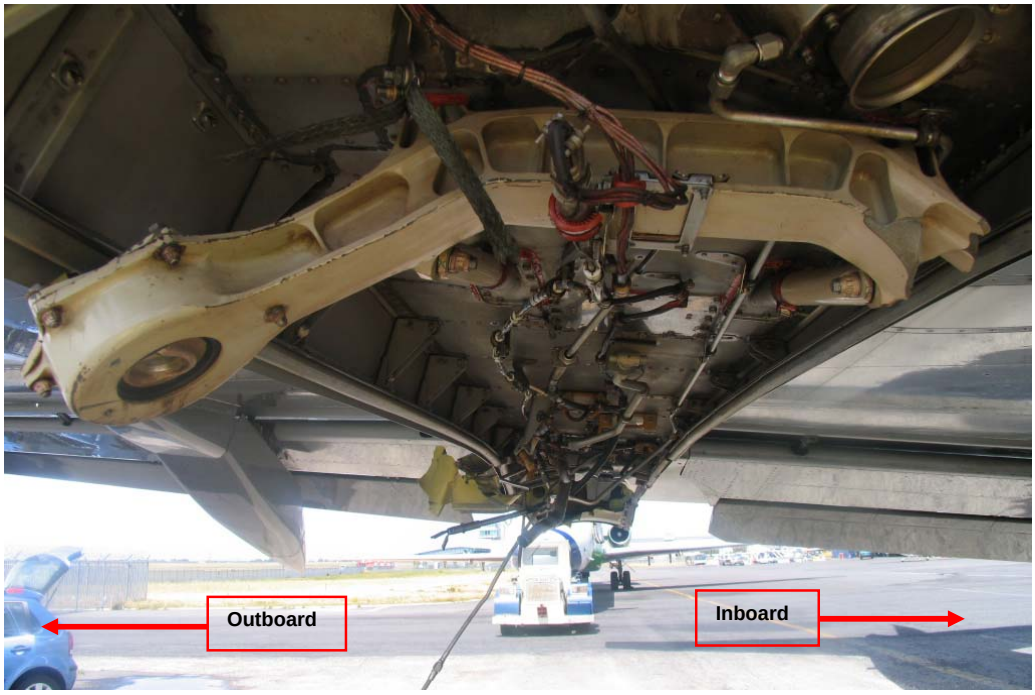


Photo 4: Fracture of the Front Engine Mount Fitting (FEMS).

1.13 Medical and Pathological Information

1.13.1 Not applicable.

1.14 Fire

1.14.1 There was no evidence of a pre- or post-impact fire.

1.15 Survival Aspects

1.15.1 The accident was regarded as survivable as the flight deck and fuselage sustained no damage and all the crew and passengers used their safety harnesses. The aircraft landed without further incident. All on board the aircraft were evacuated normally and with no further incident.

1.16 Tests and Research

1.16.1 **On-Site Investigations:**

1.16.1.1 During the visual inspection of the aircraft, the undercarriage section, the port side wing area and the engine, no significant abnormalities were observed.

1.16.1.2 The forward engine mount support fitting (FEMS) was observed to have failed (broke off) inboard of the inboard attachment point. The outboard cone bolt fractured at its shearing area, while the inboard cone bolt did not shear but remained attached to the failed (broken) inboard portion of the FEMS fitting.

1.16.1.3 The rear cone bolt failed, which would have resulted in the load transferring to the aft secondary support bolt and energy-absorbing crush core material. The aft secondary support bolt and energy-absorbing crush core material were not recovered from the accident site.

Note: According to the design features, the cone bolts should shear when the engine is overloaded, thus not compromising the structural integrity of the wing. The aft secondary support bolt and energy-absorbing crush core material are designed to support the engine in case of breakage of the aft cone bolt.

1.16.2 **Cone Bolts and Forward Engine Mount Fitting**

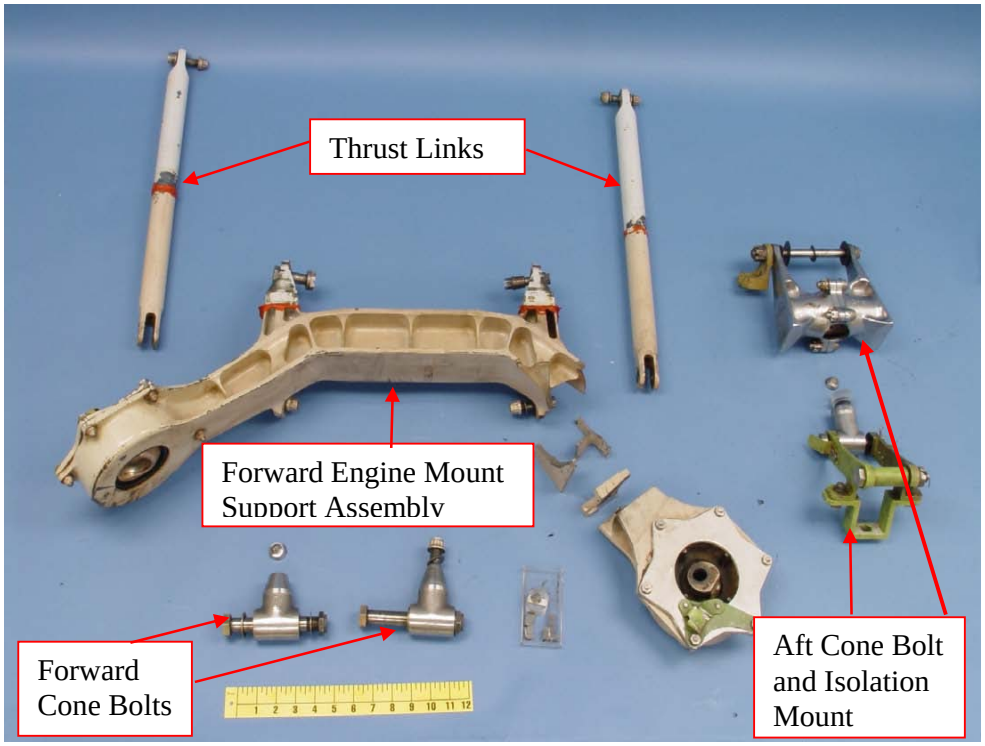


Photo 5: Overall view of the received components from the right-hand engine

1.16.2.1 Separate test analyses on the components were carried out by two metallurgists. The first examination was carried out by Facet Consulting in South Africa. The second was carried out by the National Transportation Safety Board (NTSB) of the United States of America (USA).

1.16.2.2 Boeing Commercial Airplanes was requested by the investigating team to perform a chemical analysis of samples from the three received cone bolts and the forward engine mount supporting fitting. The fractured cone bolts and the FEMS had been examined and sectioned prior to shipment to the NTSB.

1.16.2.3 The fatigue crack appeared to be very recent and its appearances suggested that it propagated under high stress conditions, resulting in rapid crack initiation and growth. Under high stress conditions due to the acceptable design conditions, a low number of cycles can result in fatigue failure. The failure occurred in the cone bolts' shear section. The failure surface of the shear section appeared to be a smooth turned surface with no indications of shot peening and no obvious damage or corrosion in the area of the fatigue origins.

1.16.2.4 The fatigue region covered an estimated 5% of the total cross section. Examinations of the fracture surface with the aid of a scanning electron microscope (SEM) revealed clear fatigue striations in the fatigue regions emanating from multiple surface origins. The remaining fracture surface was

composed mainly of cleavage facets with small areas of ductile dimple consistent with brittle overstress separation. Small shear lips were present around the periphery of the fracture outside of the fatigue regions.

1.16.2.5 The forward left (inboard) cone bolt was intact while the forward right (outboard) was fractured through the reduced diameter section, and the threaded section was not recovered (not located at the accident site).

1.16.2.6 The hardness values of the four parts (aft cone bolt, right front cone bolt, left front cone bolt and engine mount) were measured after calibration with a standard test block. The hardness value ranges and averages are indicated in the appendix. Each of the four parts was analysed for hydrogen content in a LECO TCH 600 hydrogen, oxygen and nitrogen determinator. All of the part segments had a hydrogen content of less than 1.0 ppm. This implies that hydrogen embrittlement was not a factor in the fracture of the cone bolts and engine mount.

1.16.2.8 Spectrochemical analysis of the three cone bolts confirmed that the composition of each met the requirements of the engineering drawing and AMS 5659 for 15-5PH CRES. Spectrochemical analysis of the forward engine mount confirmed the composition as meeting the requirements of BMS 7-26 as stipulated in the engineering drawing for 4340M alloy steel.

1.16.3 **Conclusions by the metallurgists:**

1.16.3.1 The hardness measurements of the three cone bolt segments and forward engine mount segments met the requirements of the engineering drawing. The compositions of the four provided part segments met the requirements of the engineering drawings and materials specifications for 15-5PH CRES and 4340M alloy steel. Metallographic analysis of the four part segments did not produce any anomalies in the 15-5PH CRES cone bolts and 4340M alloy steel forward engine mount.

Power Plant Inspection:

1.16.3.2 **Engine:**

(i). Pratt and Whitney JT8D15A, S/N: 709022; TT 43557.5; TC 35651 cycles; TT since Overhaul 3806.2 hrs; TC since overhaul 2822 cycles. Date of last repair EHM was 15 December 2004 at 39751 TT and 32829 TC.

Inspection:

(ii) The condition of the engine was inspected externally prior to disassembly, with external post-impact damage with terrain, particularly around the six o ‘clock position of the engine. As the engine had initially impacted with the terrain at that position, the accessory drive gear failed due to it being mounted in the same position.

(iii) It is the consensus of the investigation team and its co-opted participants that the damage found on the engine is the result of the impact on the runway after separation from the aircraft. It is evident that the engine was rotating at the time of impact as indicated by the bent blades, shaving on the casing and broken blades in the Low Pressure Compressor (LPC), High Pressure Compressor

(HPC), and Low Pressure Turbine (LPT) in the opposite direction of rotation.

Photo 6: Turbine blade damage and some rubbing observed during the teardown inspection.

1.16.3.3 A stall or surge condition at take-off could not be determined as the aircraft's Digital Flight Data Recorder (DFDR) did not have the capability to record the engine parameters.

(i) No evidence of foreign object deposits; bird strike or other material could be established at the engine core, engine inlet of C2 stator vanes' leading edge. Ultraviolet and visual inspection was carried out.

(ii) No evidence was found of disc, hub failure or case penetration. All damage was due to impact with the terrain after separation from the aircraft.

(iii) No further evidence of main bearing or oil system failure was identified.

CONCLUSION ON ENGINE TEARDOWN INSPECTION:

1.16.13 The engine investigation revealed that the engine was rotating prior to the accident.

1.17 Organisational and Management Information

1.17.1 Operator

1.17.1.1 The operator was the holder of an Air Operating Licence issued on 23 April 2007 by the Air Service Council in terms of the Air Service Licensing Act No 115 of 1990. The operator had a valid Air Operation Certificate (AOC, No: N276D/S275D/I/SO92) issued on 23 April 2007 in terms of Part 121 of the Civil Aviation Regulations of 1997.

1.17.1.2 The operator's records were reviewed and the evidence revealed that the incumbents of some key management positions at the operator's Aircraft Maintenance Organisation had changed frequently over the years. The position that was most affected was that of the Quality Manager where these decisions

to resign mainly occurred just before the inspection/audit for the renewal of the AMO approval.

1.17.2 Aircraft Maintenance Organisation information

1.17.2.1 According to the available records of the AMO, that was maintaining the aircraft prior to the accident, the AMO was not in possession of a valid AMO approval. The AMO's approval had expired on 30 October 2007, but the staff had continued with their activities. Subsequent to the expiry of the AMO's approval, the airworthiness inspector had issued an e-mail (07/11/07), allowing the AMO to continue to operate without a new AMO approval being issued.

1.17.2.2 During the past four years of audits by the Regulator at the AMO, major findings were identified, which were subsequently not all addressed or closed. Considering these audit findings, it is not clear why the Regulator allowed the AMO to continue with its operation.

1.17.2.3 However, the Regulator issued the AMO with a one-month authorization, commencing from 01 October 2007 until 30 October 2007. This was followed by an e-mail, sent on 7 November 2007 at 13:19 allowing the AMO to continue to operate without a new AMO approval having been issued. (Refer Appendix A). This appears to have been based on the receipt of an action report still to be considered by the Airworthiness Review Board (ARB).

1.18 Additional Information

1.18.1 According to the Airworthiness Directive (AD) 98-14-09 the accident aircraft had an old type FEMS and it required a mandatory crack inspection every 700 cycles. However, the operator failed to comply with the recommended 700 cycles as per Service Bulletin (SB) 737-54A1012, supported by the abovementioned AD. The documented evidence shows a lack of compliance of SB 737-54A1012 as supported by AD 98-14-09 regarding the accident aircraft. The dates on which the inspections were carried out are indicated below:

Insp. No	Date	Airframe Hours	Airframe Cycle	Period
	15-Oct-99	43811.7	39446	
1	29-Jun-00	45354.5	40349	903
2	23-Nov-00	46059.4	40765	416
3	24-Apr-01	Unknown	41465	700
4	16-May-01	46840.9	41237	-228
5	11-Dec-01	48009.6	41954	717
6	13-Mar-02	48372.6	42205	251

The inspections appear not to have been correctly recorded and it is apparent that there was no consistency in implementation of the AD.

No records were available to indicate whether any inspections took place from

13 March 2002 to the time of the accident. The absence of any record of inspections for 5 years prior to the accident raises a concern in respect of the safety management culture present within the AMO.

1.18.2 The exact date of the installation of the cone bolts and the cycles at the time of failure could not be established due to the lack of adequate recording and documentation.

1.18.3 It was noted that even before the accident aircraft could report “Airborne and outbound” to the control tower, another aircraft had already been cleared for landing onto the same runway.

1.18.4 The fatigue region covered an estimated 5% of the total cross section. This is much less of a fatigue region compared to the previous failures reported and investigated by NTSB, which were measured to be covering 13% of the total cross section of the fatigue region.

1.18.5 The NTSB Material Laboratory had previously examined and reported on five fractured aft cone bolts. All were identified as fatigue fractures with somewhat varying features. All displayed significantly more fatigue progression than the fracture under discussion. The smallest fatigue region on the previous fractures measured 13% of the cross section. The large shear lip is indicative of ductile final fractures on all bolts.

1.18.6 The cause of the cone bolt fatigue failures has been attributed to the cone bolt being improperly seated or loose in the conical socket, usually as a result of being improperly torqued, either under or over-torqued.

1.19 Useful or Effective Investigation Techniques

1.19.1 None

2. ANALYSIS

2.1 During the take-off and on rotation of the aircraft, a sudden spool down on all the right hand engine gauges was observed. This was followed by drastic attitude changes of the aircraft which included banking, sinking and yawing.

2.2 The aircraft twice lost altitude and the crew managed to regain control and continued with the climb to 3000 ft and maintained that altitude whilst repositioning the aircraft for the landing. The crew also informed ATC of their intention to land back on Runway 01 from an ILS approach.

2.3 The crew declared an emergency to ATC on radio frequency 119.7 MHz and informed the ATC that they would be returning to the aerodrome. The ATC enquired from the accident aircraft whether the engine was “still there or is it gone” and the reply was “It is still there” but that they were also experiencing other problems, as well as hydraulic problems.

2.4 The above communication indicated that due to poor visibility at the airport, the ATC wanted to confirm with the crew whether the engine had separated from the aircraft. However, ATC had by that time cleared another aircraft to land and then cautioned the landing aircraft about rubble on the runway. Nor the ATC or the landing aircraft opted

to initiate a go-around. This aircraft then confirmed after landing that there was a lot of rubble in the centre of the runway.

2.5 The emergency services thereafter responded and cleared the debris from the runway in preparation for the landing of the accident aircraft.

2.6 The crew advised ATC that they were safe on the ground and vacated the runway at the taxiway before coming to a stop where the emergency response personnel were already awaiting the aircraft. The passengers were informed by the cabin crew to remain calm and seated while waiting for a step ladder vehicle to arrive. The evacuation process of the passengers was conducted normally, without having to deploy the emergency escape slides. All the occupants disembarked the aircraft safely without any further incidents being reported.

2.8 Upon visual inspection it was confirmed that the right hand engine had separated from the wing. On close visual inspection it was noted that the rear engine mounting bolt, the aft secondary mounting bolt, the outboard engine mounting bolt and the secondary engine mounting had failed.

2.9 Both the aft cone bolt and the aft secondary mounting bolt (honeycomb bolt) and the front outboard cone bolt had fractured. The inboard front cone bolt was still intact, although the engine mount had failed nearer to this cone bolt.

2.10 All recovered failed components were subjected to a metallurgical examination and analysis. The metallurgical report revealed that the rear cone bolt had developed a fatigue crack. The fatigue crack appeared to be very recent and its appearance suggested that it had propagated under high stress conditions, resulting in rapid crack initiation and growth. Under high stress conditions, a low number of cycles are generally required to cause fatigue failure. The failure surface appeared to be a smooth turned surface with no indications of shot peening and no obvious damage or corrosion in the area of the fatigue origins.

2.11 The abovementioned metallurgical examination and analysis results suggest that the engine separated from the aircraft as a result of the failure of the rear cone bolt in the engine mount assembly. Subsequent to the failure of this bolt, the aft secondary bolt failed for unknown reasons (it was not available for testing) and then the forward engine mount and one of the forward cone bolts failed under overload conditions. The cause of failure of the rear cone bolt appears to be the initiation and propagation of a fatigue crack.

2.12 The test report concluded that the primary aft coned bolt failed due to a pre-existing fatigue crack.

2.13 However, the reason for the failure of the aft engine secondary support assembly could not be determined because it was not available for testing. The outboard forward bolt failed in overload as the engine swung forward during the separation sequence.

2.14 The inspections appear not to have been correctly recorded and it is apparent that there was no consistency in implementation of the AD. No records were available to indicate whether any inspections were accomplished from 13 March 2002 to the time of the incident. The absence of any record of inspections for 5 years prior to the accident raises a safety concern regarding the operational procedures, because the inspections were not carried out as per the requirements of the AD from the FAA which was

endorsed by the South African Regulator.

2.15 During the past four years of audits by the Regulator at the AMO, major findings were identified, which were subsequently not all addressed or closed. Considering these audit findings, it is not clear why the Regulator allowed the AMO to continue with its operation.

2.16 The AMO was issued a temporary authorization which was valid only for the month of October 2007. However, an airworthiness inspector of the Regulator had issued the AMO on 7 November 2007 at 13:19 with an e-mail authorising the AMO to continue with their operations even though a decision had not been made by the Airworthiness Board (ARB) as to whether the approval was going to be renewed. The relevant Civil Aviation Regulations, 1997, (CARs) Part 145 do not make any provisions for the issuance of any such e-mail authorizations or extension of a lapsed authorization or approval.

3. CONCLUSION

3.1 Findings

3.1.1 The crew members' licences were valid at the time of the accident.

3.1.2 The cone bolts attaching the engine to the airframe were the subject of an Airworthiness Directive (AD) issued by the State of Design and Manufacture of the Boeing 737 -200 aircraft and enforced by the FAA. This AD 98-14-09 was endorsed by the SACAA and applicable to South African aircraft.

3.1.3 According to AD 98-14-09, as the accident aircraft had an old type FEMS, it required a mandatory crack inspection every 700 cycles. However, the operator failed to comply with the recommended 700 cycles as per Service Bulletin (SB) 737-54A1012 supported by the abovementioned AD. The documented evidence shows a lack of compliance with SB 737-54A1012 as supported by AD 98-14-09 regarding the accident aircraft. The inspections appear not to have been correctly recorded and it is apparent that there was no consistency in implementation of the AD. No records were available to indicate whether any inspections were accomplished from 13 March 2002 to the time of the accident. The absence of any record of inspections for 5 years prior to the accident raises a safety concern regarding the operational procedures, because the inspections were not carried out as per the requirements of the AD from the FAA which was endorsed by the South African Regulator.

3.1.4 The evidence shows that the positions of key management personnel at the Nationwide Aircraft Maintenance Organisation had changed frequently over the years. The position that was most affected was that of the Quality Manager, and these decisions to resign mainly occurred just before the inspection/audit had to be done for the renewal of the AMO approval.

3.1.5 The aircraft was inspected after the accident and some of the affected components which had failed were sent for metallurgical testing and analysis. The metallurgical results and report were received and the report concluded that the aft mount cone bolt of the starboard side engine had failed due to pre-existing fatigue cracks. According to the report, the consequences of this failure (aft cone bolt) had imposed uneven stress loading and imbalances on the front engine's mounting mechanism and structure.

3.1.7 The imbalances on the front engine mounting structure, when assessed in relation to the engine torque force, had imposed rotational stress (upwards on inboard bolt and downward on outboard bolt, also gyroscopic force) loading to the front mounts. These loads were due to the engine lowering below its original horizontal plane, thus hanging only on the front mounts while subjected to a rotational force and a forward thrust which was not horizontally forward but slanted or pitched up due to the rear "hanging effect". These loads caused the cracked forward engine mount to fail. The outboard forward cone bolt failed in overload due to the failure of the forward engine mount at the cracked location and as the engine swung forward during the separation sequence.

3.1.8 The damage found on the engine is the result of the impact on the runway after separation from the aircraft. It is evident that the engine was rotating normally at the time of impact as indicated by the bent blades and broken blades of the Low Pressure Compressor (LPC), High Pressure Compressor (HPC), High Pressure Turbine (HPT) and Low Pressure Turbine (LPT) in the opposite direction of rotation. There were no pre-existing failures of the engine prior to separation from the airplane.

3.1.9 The AMO had been issued with a temporary approval which was valid only for the month of October 2007. However, on 7 November 2007 at 13:19 an airworthiness inspector of the Regulator had issued the AMO with an e-mail authorising the AMO to continue with its operations, even though a decision had not been made by the ARB as to whether the approval was going to be renewed. This was done notwithstanding the long history of major audit findings which were not fully addressed.

3.1.10 During the past four years of audits by the Regulator at the AMO, major findings were identified, which were subsequently not all addressed or closed. Considering these audit findings, it is not clear why the Regulator allowed the AMO to continue with its operation.

3.1.11 No AMO approval was in existence for the period 1 to 7 November 2007, as the relevant CARs Part 145 do not make any provisions for the issuance of extensions of a lapsed approval or the granting of an authorization by e-mail.

3.1.12 Subsequent to the accident the SACAA suspended the approval for the Nationwide Aircraft Maintenance Organization (AMO) with effect from midnight 29 November 2007, in terms of Part 145 of the Civil Aviation Regulations. Furthermore, the SACAA suspended the Certificates of Airworthiness of aircraft maintained by the AMO in terms of Part 21, effective midnight 29 November 2007. As a result of this action the aircraft that constituted the Nationwide air fleet was not permitted to undertake any further flights until their airworthiness status has been verified. No further failures of cone bolts were identified.

3.1.13 The oversight activities as implemented by the SACAA did not in all respects meet or ensured compliance with the applicable regulatory requirements.

3.2 Probable Cause/s

3.2.1 The right-hand engine separated from the aircraft due to the failure of the aft cone bolt as a result of a pre-existing fatigue crack which was most likely caused by incorrect installation of the cone bolt.

4. SAFETY RECOMMENDATIONS

It is recommended that:

4.1 The Commissioner for Civil Aviation strengthens the capability of the SACAA to ensure adequate safety oversight and compliance by operators with regard to safety requirements and directives.

4.2 The Airworthiness Department of the SACAA introduces a procedure which will address the issuance of approvals via e-mail.

4.3 The Commissioner for Civil Aviation should initiate a minimum standard (Safety Management System) procedure that could assist and educate the operators to manage risk within their operations.

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Report reviewed and amended by the Advisory Safety Panel
30 October 2009

Appendix A: **E-mail approval**

Martin Bezuidenhout

From: Martin Bezuidenhout
Sent: Wednesday, November 07, 2007 3:19 PM
To: 'leon kemp'
Subject: RE: FALA AMO225

Hallo Leon

I have received your action report and I am just trying to get an ARB together to complete the process. You can continue with your operation until such time that the new AMO Certificate is printed once approved by the Commissioner. I will keep you informed.

Martin Bezuidenhout
Airworhtiness Inspector
Tel: +27 (0)11 545 1000
Fax: +27(0)11 545 1461
Cell: +27 0836312349
E-mail: BezuidenhoutM@caa.co.za

From: leon kemp [mailto:lkemp@nationwideair.co.za]
Sent: Tuesday, November 06, 2007 10:49 AM
To: Martin Bezuidenhout
Cc: Albert Msithini
Subject: FALA AMO225

Hi there Martin,
I trust our corrective action plan was in order and hopefully our Certificate is in the progress of being issued, or am I a bit optimistic?
Please will you let me know if there is anything else you require from us.

Kind regards,

Leon Kemp
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+27-(0)84-400-0645 – Mobile
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11/8/2007