

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



الهيئة العامة للطيران المدني
GENERAL CIVIL AVIATION AUTHORITY

Air Accident Investigation Sector - Final Incident Report -

AAIS Case File 14/2011

Tire Burst during Landing

Boeing 777-300

A6-EMR

Emirates

Ibrahim Nasir International Airport
(MLE) Maldives

02 December, 2011

رؤيتنا: منظومة طيران مدني آمنة ورائدة ومستدامة
OUR VISION: A LEADING, SAFE, SECURE AND SUSTAINABLE CIVIL AVIATION SYSTEM

INCIDENT

NAME OF THE OPERATOR : Emirates
MANUFACTURER : Boeing
AIRCRAFT MODEL : B777-300
NATIONALITY : UAE
REGISTRATION : A6-EMR
STATE OF OCCURANCE : Maldives
LOCATION COORDINATES : 04°11'30"N 073°31'45"E
(On the runway of MLE Airport)
DATE & TIME : 02nd December 2011, 22:35
Local Time

Notes:

1. All times in the report are Local Time (Local time in MLE was UTC+5h)
2. The word "Aircraft" in this report implies the aircraft involved in the incident
3. The word "Team" in this report implies the Investigation Team
4. This report is based on the Operator's and the Tire Manufacturer's reports.

OBJECTIVE

This investigation is performed was performed pursuant to the UAE Federal Act No 20 (1991), promulgating the Civil Aviation Law, Chapter VII, Aircraft Accidents, Article 48, CAR Part VI Chapter 3, in conformity with Annex 13 to the Convention on International Civil Aviation and in adherence to the Air Accidents and Incidents Investigation Manual.

The object of this safety investigation is to prevent aircraft accidents and incidents by identifying and reducing safety-related risk. The GCAA AAIS investigations determine and communicate the safety factors related to the transport safety matter being investigated.

Reports are publicly available from:

<http://www.gcaa.gov.ae/en/epublication/pages/investigationreport.aspx>

It is not a function of the GCAA AAIS to apportion blame or determine liability.

The information contained in this Final Report is derived from the factual information gathered during the investigation of the occurrence.

Contents

OBJECTIVE	3
List of Figures.....	5
List of Tables	5
List of Photos.....	6
ABBREVIATIONS	8
Synopsis	10
1.0 Factual Information	11
1.1 History of the Flight.....	11
1.2 Injuries to Persons.....	12
1.3 Damage to Aircraft.....	12
1.3.1 Tires.....	13
1.3.2 Junction Boxes.	28
1.4 Other Damage.....	30
1.5 Personnel Information	31
1.6 Aircraft Information.....	31
1.7 Meteorological Information.....	31
1.7.1 General Meteorological Situation at the destination airport (MLE).	31
1.7.2. Meteorological Reports on 2 Dec 11.....	32
1.8 Aids to navigation.....	33
1.9 Communications.....	33
1.10 Aerodrome Information	33
1.11 Flight Recorders	34
1.12 Wreckage and impact information.....	34
1.13 Medical and Pathological Information.....	35
1.14 Fire	35
1.15 Survival aspects.....	36
1.16 Tests and Research.....	36
1.16.1 Junction Box Damage Analysis.	36
1.16.2 Band Clamp Testing.....	36

1.17	Organizational and management information.....	36
1.18	Additional Information.....	38
1.18.1	Hydroplaning	38
1.18.2	Accidents due to wet runways / standing water	38
1.19	Useful or effective investigation techniques	39
2	ANALYSIS.....	40
2.1	Crew Actions.....	40
2.1.1	Male runway condition.....	40
2.2	B777 Junction Boxes	41
3	CONCLUSIONS.....	41
3.1	Findings	41
3.2	Causes and Contributing factors.....	42
4	SAFETY RECOMMENDATIONS.....	42
4.1	Safety Actions Taken.	42
4.2	Safety Recommendations.....	43

List of Figures

Figure 1.	Photos indicating the condition of the landing gears' hubs and tires at Male airport prior to removal from the aircraft.....	12
Figure 2.	B777 (left) landing gear	13
Figure 3.	B777 landing gear junction box.....	29
Figure 4.	B777 landing gear Junction box side view.	29
Figure 5.	Google Earth image general location of Male Airport	33
Figure 6	Google Earth Image Male Airport, detail.	34
Figure 7.	Google Earth image with approximate position of the recovered junction boxes, runway damage and the landing point.	35

List of Tables

Table 1.	Injuries to Persons.....	12
Table 2.	Tire Positions and Manufacturer	13

Table 3. Tires wear level	28
Table 4. Crew members flying time the last 90, 28, 7 days and 24 hours.	31
Table 5. Rainfall before and at the time of the incident.	32

List of Photos

Photo 1. Tire position 1	14
Photo 2. The two sides of the same torn portion Tire position 1	14
Photo 3. High Temperature signature on Tire position 1	15
Photo 4. Flat Spot on Tire position 1	15
Photo 5 Bead Cores broken tire position 1	16
Photo 6. The two small parts of the three recovered of the tire position 1.	16
Photo 7. Detail of one part of the two dislocated parts Tire position 1.	17
Photo 8. Tire position 2 broken in four parts.....	17
Photo 9. The two smaller parts of Tire position 2.	18
Photo 10. The two large parts of Tire position 2.	18
Photo 11. Tear down of the crown plies, Tire position 2.....	19
Photo 12. Flat spot, Tire position 2.	19
Photo 13. Flat Spot heated areas Tire position 2.	20
Photo 14. Total dislocation, Tire position 2.	20
Photo 15. 700 mm long flat spot, Tire position 5.....	21
Photo 16. Flat Spot heated rubber, Tire Position 5.	21
Photo 17. Opposite serial Number friction cut, Tire Position 5.....	22
Photo 18 Sidewall on the serial number side friction cut, Tire Position 5.	22
Photo 19 Wrinkles, Tire Position 5.	23
Photo 20. Rupture, Tire Position 5.	23
Photo 21. Tire Position 5.....	24
Photo 22. Detail Tire Position 5.	24
Photo 23. Opposite serial number sidewall friction mark, Tire Position 6.....	25
Photo 24. Tire Position 9.....	25
Photo 25. Raped areas and Chevron cutting detail tire position 9.....	26

Photo 26. Shoulder cut on the opposite serial number side, tire position 9. ...	26
Photo 27. Tire position 10.....	27
Photo 28. Rased areas on Tire Position 10.....	27
Photo 29. Damage on the runway surface.....	30
Photo 30. Runway 18 threshold area showing the damage on the runway surface.	30
Photo 31. Recovered junction boxes from A6EMR.	37

ABBREVIATIONS

aal	above airfield level
ABS	Auto Brake System
ACFT	Aeroplane
AAIS	UAE GCAA Air Accident Investigation Sector
AFM	Aircraft Flight Manual
AMM	Aircraft Maintenance Manual
AMO	Approved Maintenance Organization
AMS	Approved Maintenance Schedule
amsl	above mean sea level
AOC	Air Operator's Certificate
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATPL	Air Transport Pilot License
AVOL	Aerodrome visibility operational level
BEA	Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile
CAAP	Civil Aviation Advisory Publication
CAR	UAE Civil Aviation Regulation
CAR-OPS	UAE Civil Aviation Regulation – Flight Operation
CAT	Category
CAVOK	Cloud and Visibility OK
CFI	Certificated Flight Instructor
CG	Centre of Gravity
C of A	Certificate of Airworthiness
COM	Communication
CRJ	Canadair Regional Jet (The Bombardier)
CRM	Cockpit Resource Management
CVR	Cockpit Voice Recorder
Cm	centimetre
CMR	Certificate of Maintenance Review
DGCA	Directorate-General of Civil Aviation of India
EICAS	Engine Indicating and Crew Alerting System
ELP	English Language Proficiency
FAA	Federal Aviation Administration
FDR	Flight Data Recorder
FSF	Flight Safety Foundation
Fwd	forward
GCAA	UAE General Civil Aviation Authority
GCC	Gulf Cooperation Council
hrs	hours
ICAO	International Civil Aviation Organization
IIC	Investigator In Charge
ILS	Instrument Landing System
JAA	Joint Aviation Authorities
kg	kilogram

KIAS	Knots Indicated Air Speed
Knts	Knots
Km	kilometers
LDA	Landing Distance Available
Ldg	Landing
LH	Left Hand
LT	Local Time
m	metres
mb	millibars
MCC	Multi Crew Co-operation
METAR	METEorological Aerodrome Report
MHz	Mega Hertz
MLE	Male Airport, Maldives
MLG	Main Landing Gear
MSI	Major Structural Inspection
MSN	Manufacturer Serial Number
NLR	The Dutch National Aerospace Laboratory
No.	Number
n°	Number
OK	all correct
PAPI	Precision Approach Path Indicator
QNH	barometric pressure adjusted to sea level
RH	Right Hand
ROSI	UAE Mandatory Reporting of Safety Incident System
S/E	Single Engine
SN	Serial Number
SOP	Standard Operating Procedures
SMGCS	Surface Movement Guidance and Control System
TAF	Terminal Aerodrome Forecast
TO	Take Off
TSO	Time Since Overhaul
TSN	Time Since New
T1	Training Area 1
UAE	United Arab Emirates
UTC	Co-ordinated Universal Time
VHF	Very High Frequency
VOR	Very High Frequency Omnidirectional Range (Navigation System)

Synopsis

The General Civil Aviation Authority (GCAA) Air Accident Investigation Sector (AAIS) was informed of the incident via the United Arab Emirates (UAE) Mandatory Reporting System, (ROSI)¹ and took over the investigation of the incident on 05th December 2011 at the request of the State of Occurrence, Maldives, as per ICAO Annex 13 paragraph 5.1. In accordance with ICAO Annex 13, The State of the Manufacturer (United States of America) was notified and assigned an Accredited Representative to the investigation. The State of Occurrence also assigned an Accredited Representative. At a later stage, the State where the tires were manufactured was notified and asked to assist in the investigation. The request was accepted and an Accredited Representative was appointed. The UAE GCAA AAIS was the lead investigation agency and issued the final report.

During the approach to the destination airport the crew members were informed by ATC that the landing runway was wet and during the landing of the Boeing 777-300 on runway 36 at Male airport on 2 Dec 2011, the left main landing gear suffered damage. The aircraft was stopped in the vicinity of the runway 18 threshold after an 180° back-track turn. The aircraft engines were shutdown at that location and upon inspection, the ground engineer informed the crew of damage to the landing gear. Passengers were disembarked and taken to the airport terminal.

No injuries to flight crew, passengers and ground staff were reported as a result of the incident. A total of 17 crew and 232 passengers were onboard the aircraft.

This investigation report describes the factual information and safety actions taken by the Aircraft Operator, the Airport Operator and the Aircraft Manufacturer.

Two Safety Recommendations were made as a result of this investigation:

To the GCAA:

GCAA should ensure that all UAE Operators utilising Male as a destination or/and as an en-route or destination alternate are aware of the results of this investigation.

And to

The Maldives Civil Aviation Authority

Until the runway enhancements are finalised, the Maldives Civil Aviation Authority should ensure that Operators utilising Male airport are fully aware of the runway condition.

¹ The supporting documentation for ROSI may be found in :

[http://www.gcaa.gov.ae/en/ePublication/_layouts/GCAA/ePublication/DownloadFile.aspx?Un=/en/ePublication/admin/Library/Pdf/CivilAviationAdvisoryPublication\(CAAP\)/CAAP22SAFETYINCIDENTREPORTING.pdf](http://www.gcaa.gov.ae/en/ePublication/_layouts/GCAA/ePublication/DownloadFile.aspx?Un=/en/ePublication/admin/Library/Pdf/CivilAviationAdvisoryPublication(CAAP)/CAAP22SAFETYINCIDENTREPORTING.pdf)

1.0 Factual Information

1.1 History of the Flight

The flight departed at 16:27GMT on 02nd December 2011, from Colombo, Sri Lanka (IATA airport code CMB, ICAO airport code VCBI) airport on a scheduled service destined for Malé International Airport, Maldives (IATA airport code MLE, ICAO airport code VRMM).

No abnormalities were reported by the crew during the flight and as the aircraft approached Male and passing through 6000 feet, ATC information on the weather conditions was communicated to the crew. At this time, the runway was wet with tailwinds of up to 8 knts.

The crew recalculated the landing performance with auto-brake selection 4 (ABS4). The calculation indicated that the performance would be acceptable and the crew decided to continue the approach. The wind was monitored during the approach, checked with ATC and just prior to touchdown the wind given approximately from 210° at 5 knts. The landing was made in the touchdown zone and was described by both crew members, as 'normal'. Full reverse was selected but the crew stated that the braking action which occurred was not as expected for an ABS4 setting. Aside from the intensity of the braking being less than expected, the crew stated that the initial roll-out was otherwise normal.

Approximately halfway along the runway, at around 90 knts, the Pilot Monitoring (First Officer) called 'EICAS autobrake' and the Flying Pilot (Captain) initiated manual braking. Approximately 2 seconds after this, the First Officer called 'EICAS antiskid' with an EICAS 'Auto speed brake' message. The Captain manually decelerated to a slow taxi speed for the required 180° turn on the runway. Halfway through the turn, the aircraft was felt to be skidding slightly. After the turn, the crew observed tire debris on the runway and, as the aircraft did not feel normal, a complete stop was made.

Another crew confirmed that there was debris at the beginning of runway 36. The ATCO (Tower) was informed at which time the ground maintenance crew was approaching the B777. The ground engineer informed the crew that the Left Hand Main Landing Gear tires 1 and 2 had separated from the wheel hubs and that there was other damage to the MLG.



Figure 1. Photos indicating the condition of the landing gears' hubs and tires at Male airport prior to removal from the aircraft.

As the aircraft could not move under its own power, the passengers and crew were disembarked and taken to the airport terminal.

At this time MLE airport was closed to all traffic.

The aircraft was subsequently recovered by replacement of all damaged parts.

1.2 Injuries to Persons

Injuries	Flight Crew	Cabin Crew	Passengers	Other	Total
Fatal	0	0	0	0	0
Serious	0	0	0	0	0
Minor	0	0	0	0	0
None	2	15	232	0	249

Table 1. Injuries to Persons

1.3 Damage to Aircraft

For orientation, the tire numbering and position on the B777 can be seen in figure 2. As reported by the ground crew, the left hand (LH) Main Landing Gear (MLG) positions 1 and 2 tires had separated from their hubs, tire position 5 was damaged but still on the hub and both forward (fwd) junction box, J501, and aft

junction box, J503, were missing. All missing parts were later retrieved from the runway.



Figure 2. B777 (left) landing gear

1.3.1 Tires

The aircraft was fitted with Michelin tires the size of which was 50x20.0R22/32/235 and the Part Number was M12301 Ind 02. In more detail (see Table 2. Tire Positions and Manufacturer):

Serial Number	Casing Manufacturer	Retread Center	R-Level	Wheel Position
1164S042	Michelin Nong Khae	N/A	R00U	1
0357S047	Michelin Nong Khae	N/A	R00U	2
1075S033	Michelin Nong Khae	N/A	R00U	5
9302W037	Michelin Nong Khae	Michelin Bourges	R01UMBO/ 06.11	6
1179S040	Michelin Nong Khae	N/A	R00U	9
0340C263	Michelin Bourges	N/A	R00U	10

Table 2. Tire Positions and Manufacturer

As per the examination report² of the six tires sent to the tire manufacturer under the supervision of BEA³ three of the tires had burst (positions 1, 2 & 5) and the other three (positions 6, 9 & 10) retained pressure. The examination of the three burst tires revealed the following:

SN: 1164S042 (position no.1) consisting of three recovered parts (photo 1).

² Tire Analysis Report number 312-043 dated 19 April 2012.

³ The French Authority responsible for safety investigations into accidents or incidents in civil aviation.



Photo 1. Tire position 1

A large part of the tire (approximately a quarter of the circumference) was missing (see photo 1). On the larger tire piece (see photo 2), the wrenching/tearing of all the crown plies (textile & metallic) were visible.

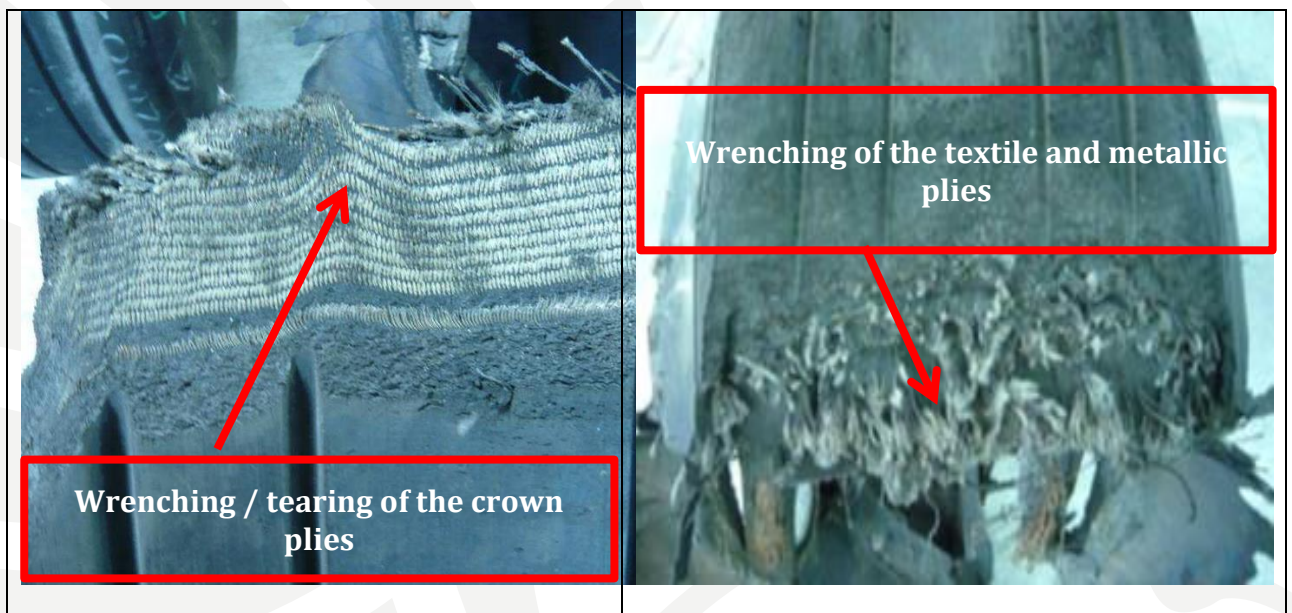


Photo 2. The two sides of the same torn portion Tire position 1

On both sides of this damaged area, the rubber exhibited locally a signature of high temperatures with marks of rasped areas on the tread (photo 3).

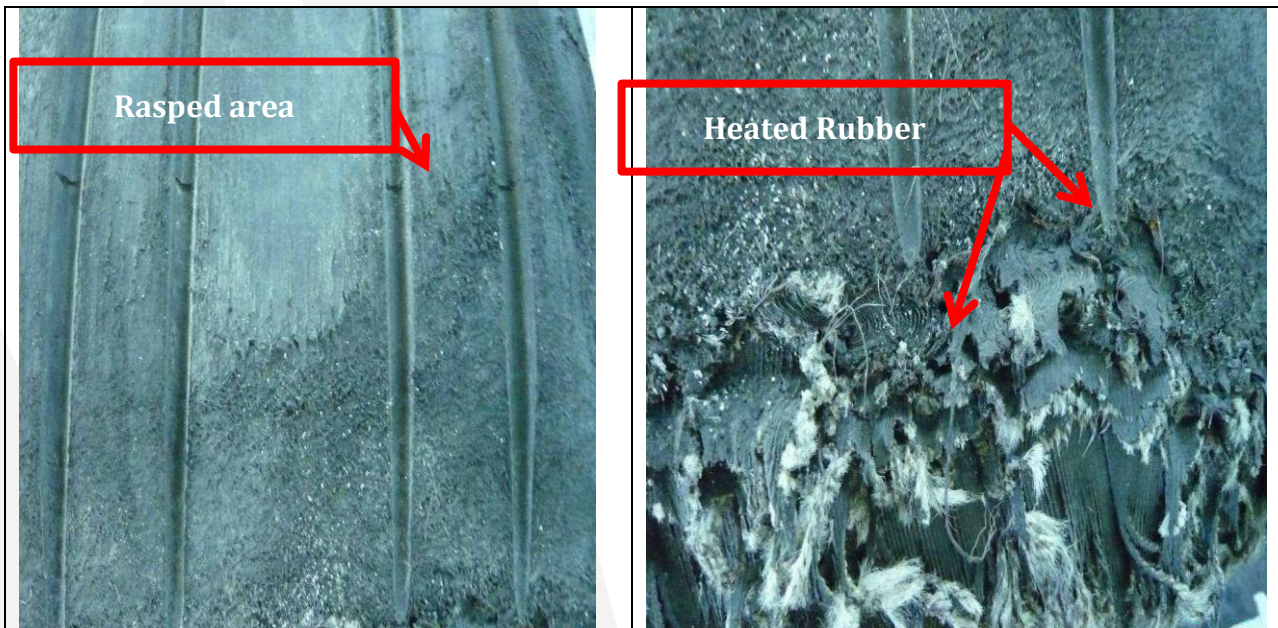


Photo 3. High Temperature signature on Tire position 1

A second area of flat spotting, 280 mm long, is visible on the tread of the tire with tearing down to the crown plies (see photo 4).

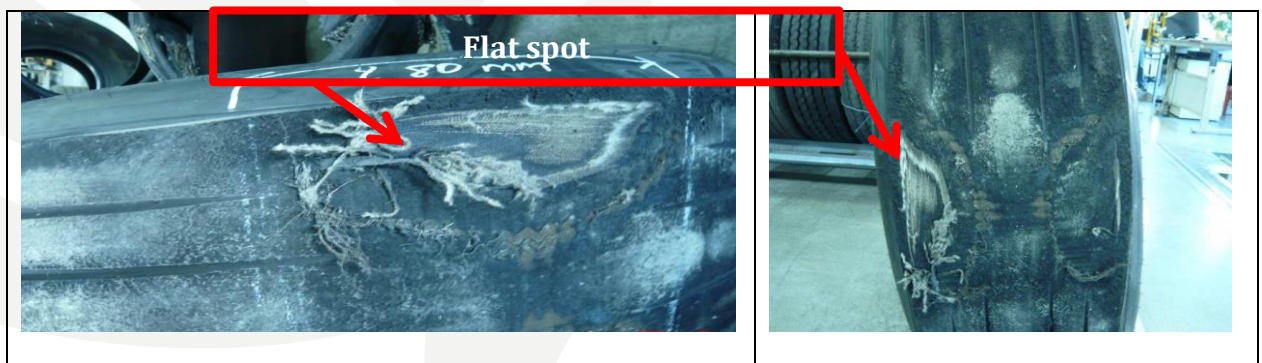


Photo 4. Flat Spot on Tire position 1

The dislocation of the tire was major with the beads ruptured and worn through on a quarter of the circumference (see photo 5).

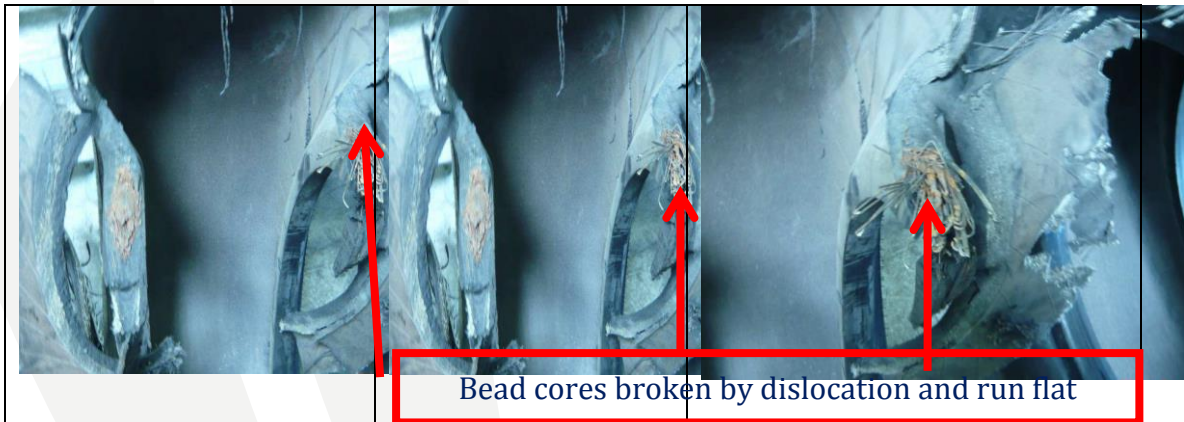


Photo 5 Bead Cores broken tire position 1

The two other pieces (photo 6) separated from the tire during the dislocation.



Photo 6. The two small parts of the three recovered of the tire position 1.

One of these tires recovered parts also shows some tearing of the crown plies (photo 7).



Wrenching of the crown plies

Photo 7. Detail of one part of the two dislocated parts Tire position 1.

SN: 0357S047 (position n°2):
The tire was recovered in four parts (photo 8).



Photo 8. Tire position 2 broken in four parts.

The two smaller parts separated from the tire during the dislocation (photo 9).



Photo 9. The two smaller parts of Tire position 2.

The two larger parts are the tread package and the tire carcass which were separated from each other during the dislocation (see photo 10).



Photo 10. The two large parts of Tire position 2.

The tread has a radial rupture with tearing down to the crown plies (textile & metallic) (photo 11).

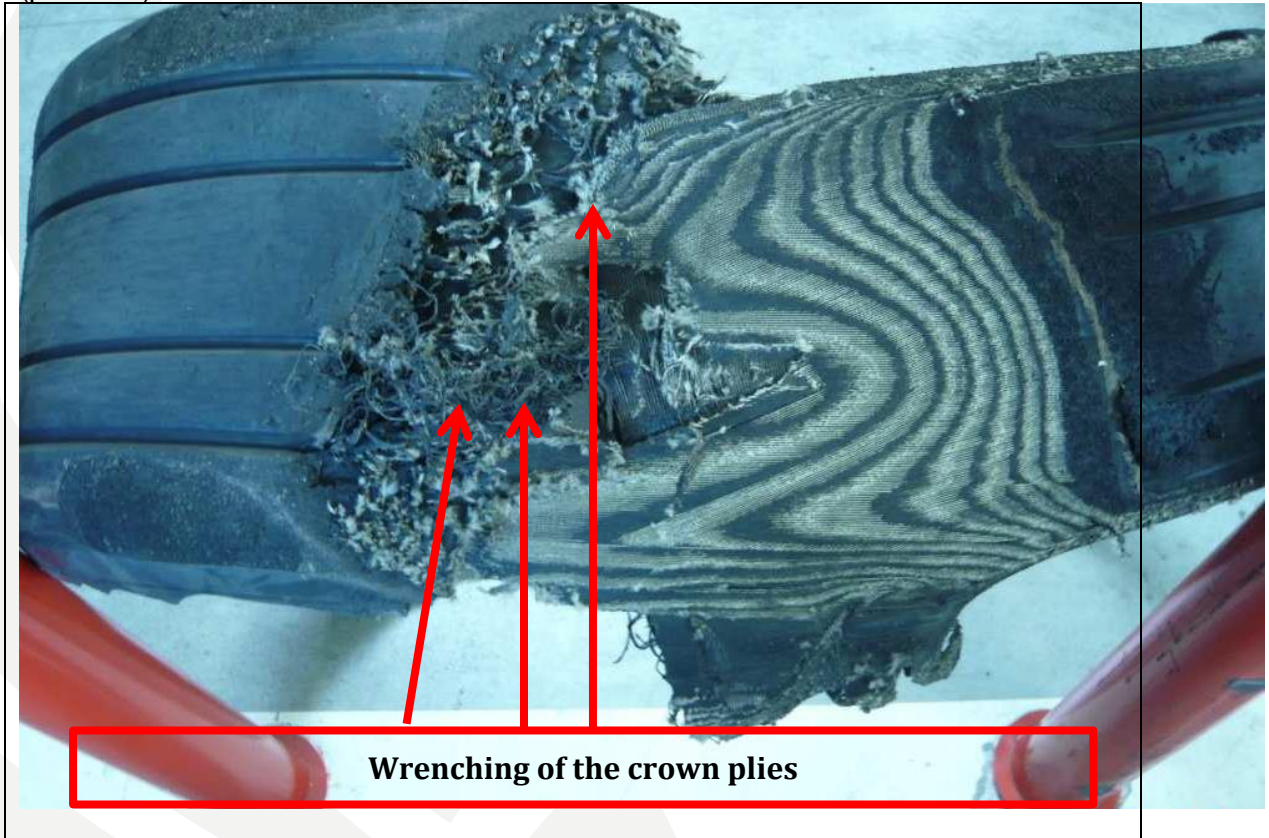


Photo 11. Tear down of the crown plies, Tire position 2.

The broken portion of the tread is associated with a major flat spot (photo 12).

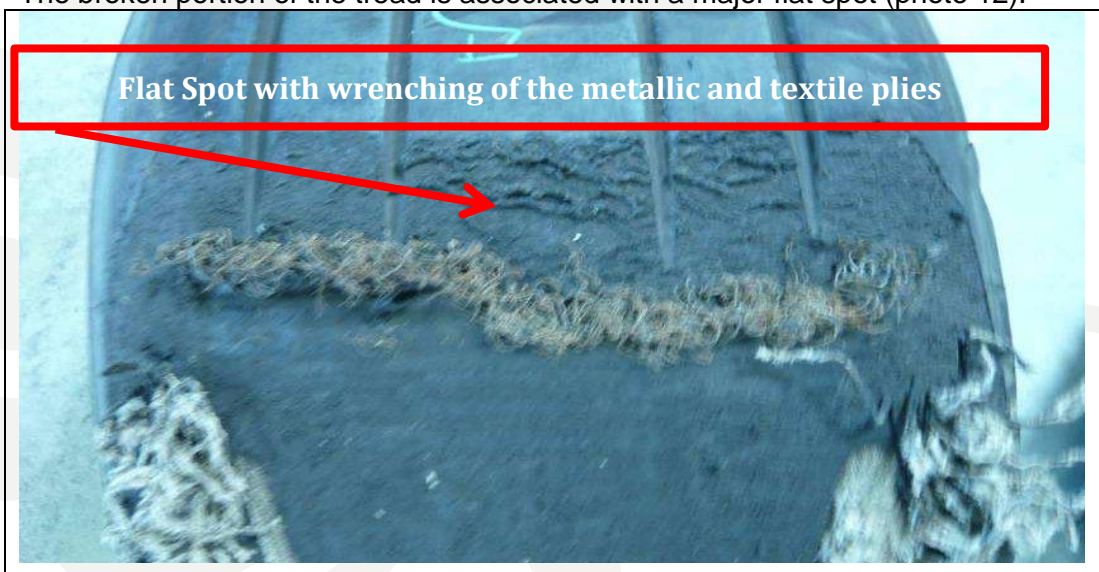


Photo 12. Flat spot, Tire position 2.

Another large flat spot area, 405mm long, with wrenching of the crown plies was also visible on the tread. In both flat spot areas, the rubber exhibits locally a signature of high temperatures with clear marks of rasped areas (photo 13).

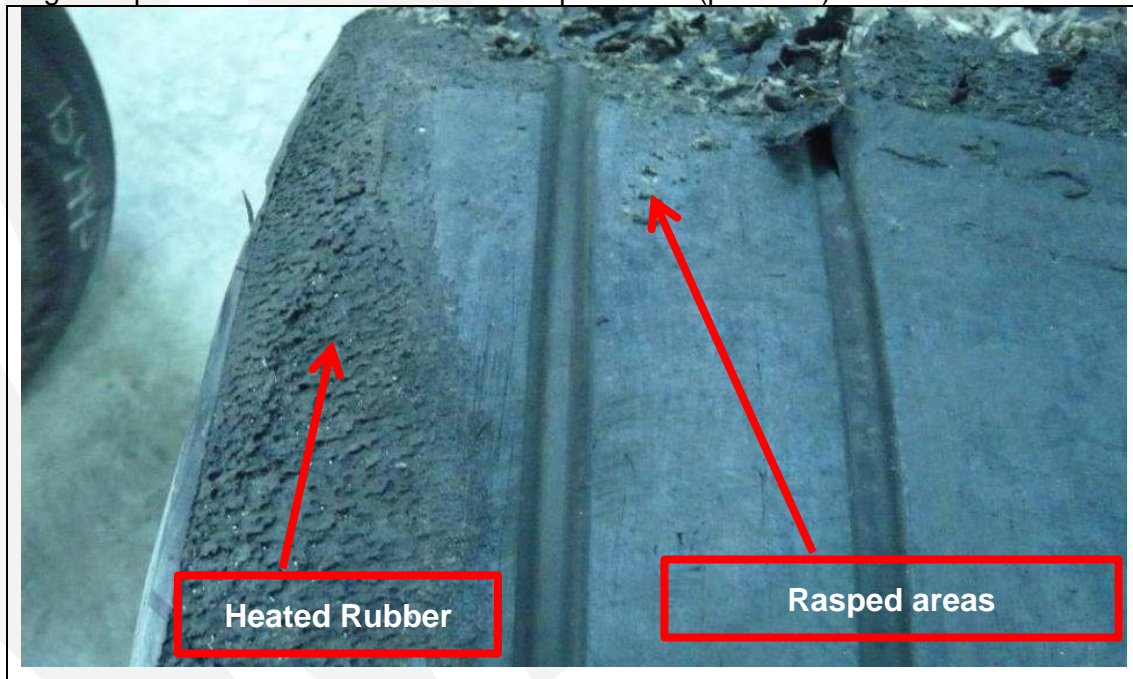


Photo 13. Flat Spot heated areas Tire position 2.

A total dislocation of the carcass of the tire is observed with broken bead cores (photo14).



Photo 14. Total dislocation, Tire position 2.

SN: 1075S033 (position n°5):

The tire is ruptured in the center of the tread at a 700 mm long flat spot area. This rupture reaches the crown plies.

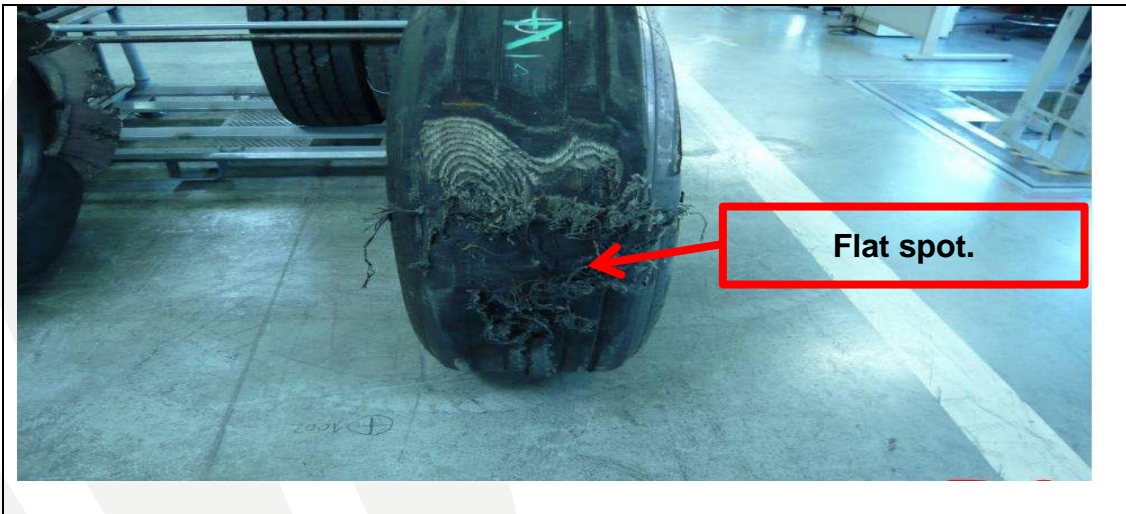


Photo 15. 700 mm long flat spot, Tire position 5.

On both sides of this area, the rubber exhibits locally a signature of high temperatures with clear marks of rasped areas on the tread (photo 16).



Photo 16. Flat Spot heated rubber, Tire Position 5.

On the two sidewalls near the rupture there are two depressions probably caused by the run flat opposite serial number side: 270 mm long with a width of 30 mm (photo 17).



Photo 17. Opposite serial Number friction cut, Tire Position 5.

- Serial number side: 295 mm long with a width of 30 mm (photo 18).



Photo 18 Sidewall on the serial number side friction cut, Tire Position 5.

Wrinkles were also visible on the inner liner (photo 19).

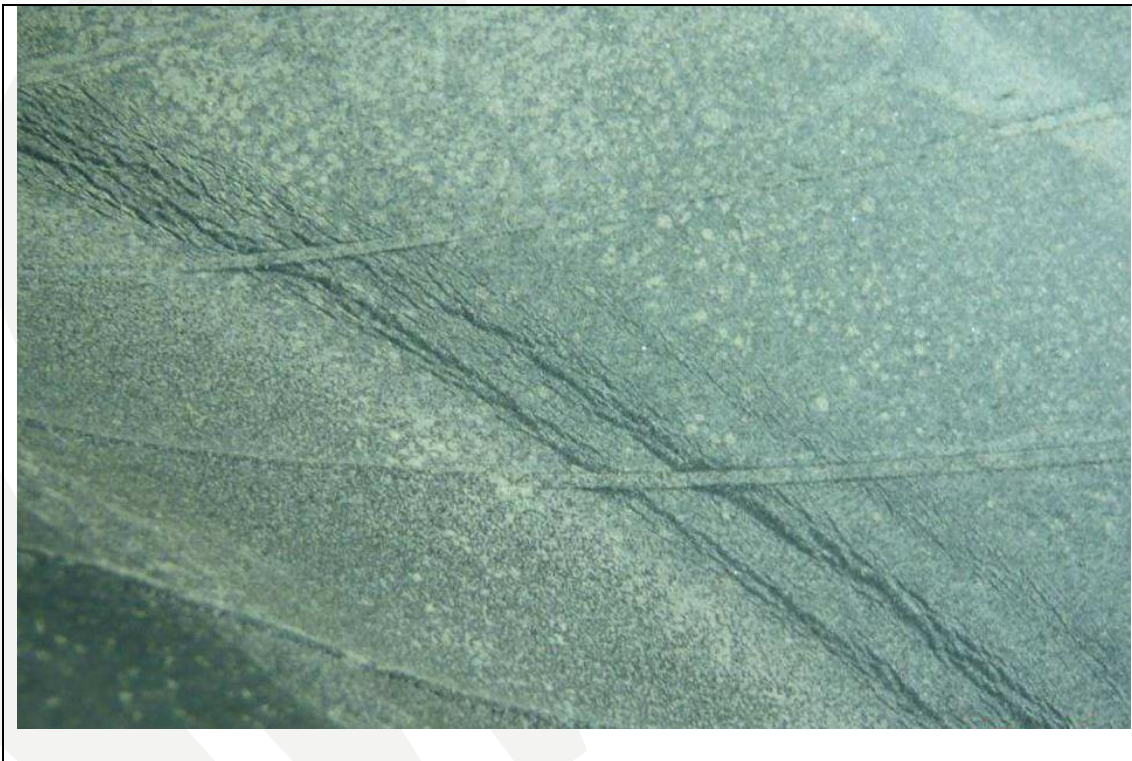


Photo 19 Wrinkles, Tire Position 5.

The rupture has reached the inside of the tire (photo 20).

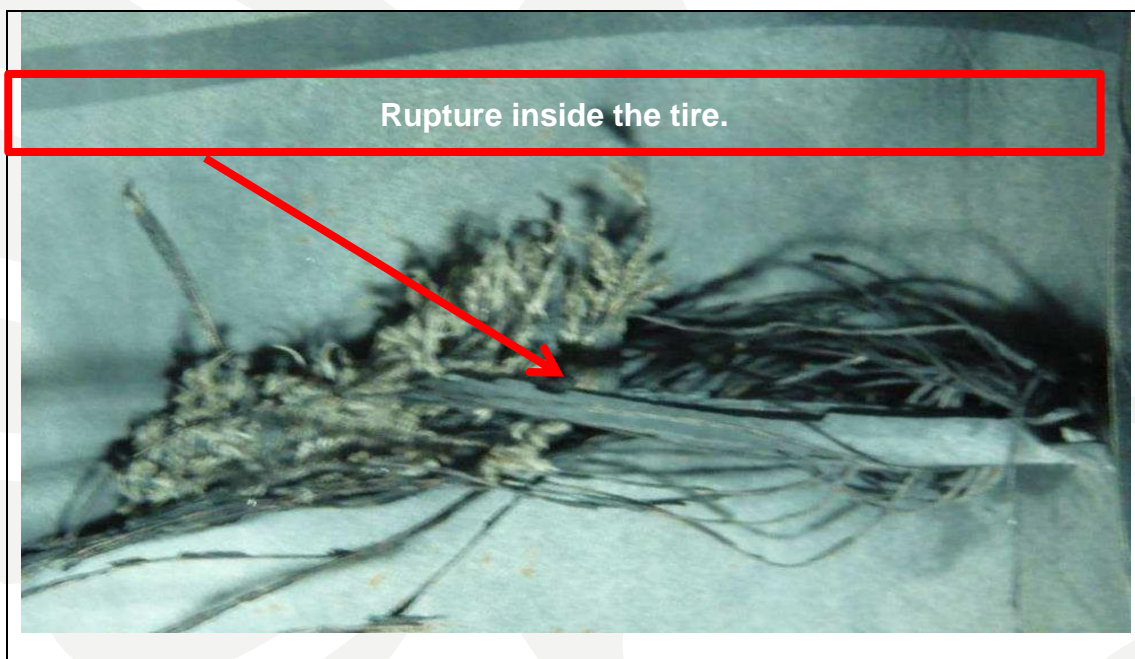


Photo 20. Rupture, Tire Position 5.

Other tires:

SN: 9302W037 (position n°6): The tire is partially worn (photo 21).



Photo 21. Tire Position 5.

Some rasped areas are visible and some pieces of rubber are stuck to the tread (photo 22).

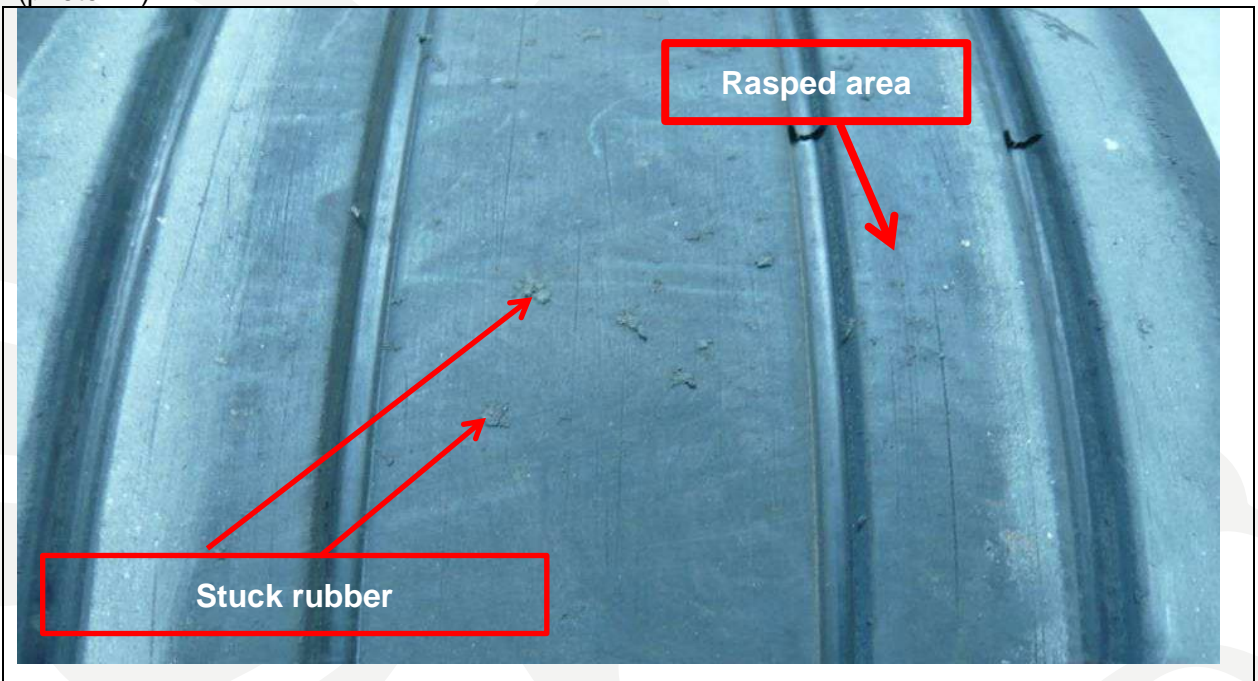


Photo 22. Detail Tire Position 5.

At the top of the opposite serial number side, a zone of circumferential friction is visible (photo 23).



Photo 23. Opposite serial number sidewall friction mark, Tire Position 6.

SN: 1179S040 (position n°9): The tire was partially worn (photo 24).



Photo 24. Tire Position 9.

Some rasped areas and chevron cutting are visible on the thread (photos 25).

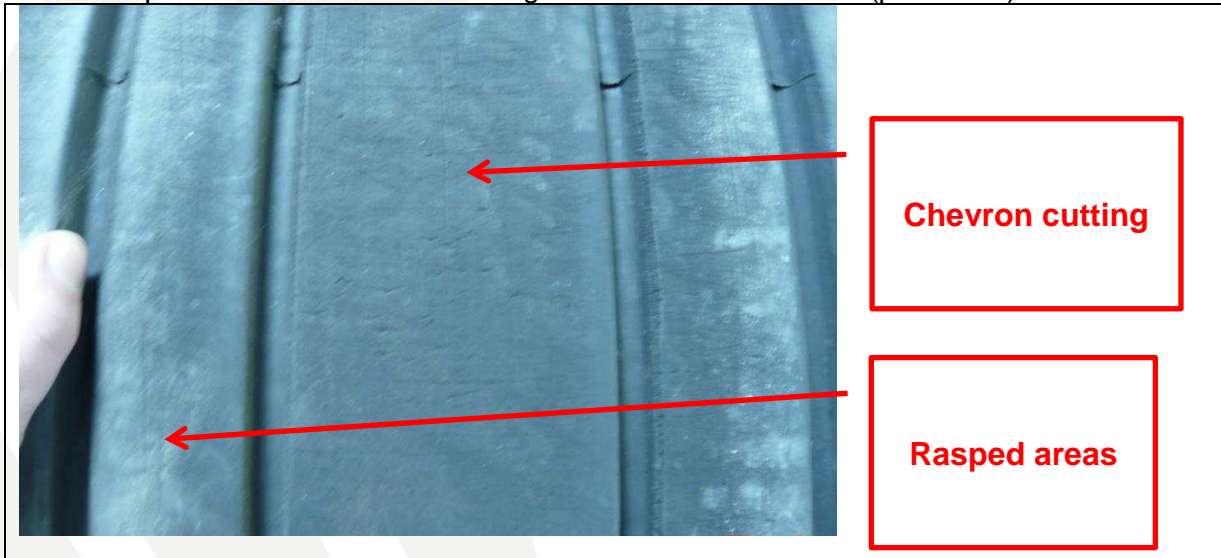


Photo 25. Rasped areas and Chevron cutting detail tire position 9.

A 200 mm long cut is situated on the shoulder on the opposite serial number side (photo 26).



Photo 26. Shoulder cut on the opposite serial number side, tire position 9.

SN: 0340C263 (position n°10): The tire was partially worn (photo 27).



Photo 27. Tire position 10.

Some rasped areas are visible on the tread (photo 28).



Photo 28. Rasped areas on Tire Position 10.

The manufacturing and retread records were reviewed and found to meet specifications.

Serial Number	Wheel Position	Skid Depth New	Skid returned (max/min)	Percent Worn	Number of Landings
1164S042	1	11.93 mm	9.7/0.0 mm	20/100 %	75
0357S047	2	11.93 mm	5.3/0.0 mm	55/100 %	165
1075S033	5	11.93 mm	5.8/0.0 mm	50/100 %	169
9302W037	6	13.20 mm	10.1/8.3 mm	25/40 %	83
1179S040	9	11.93 mm	9.6/7.2 mm	20/40 %	09
0340C263	10	11.93 mm	11/10 mm	05/15 %	09

Table 3. Tires wear level

The three burst tires exhibit similar damage. The partially detached crown package and the damage signature are characteristic of abrasions due to flat spotting.

The examination performed at the Michelin shop showed no evidence of tire related discrepancies from the specification.

Therefore, the damages are related to a cause external to the tires.

The other three tires remained inflated. They fully met performance expectations by successfully carrying the overload without any significant damage.

1.3.2 Junction Boxes.

Outline of Function of B777 'Junction Boxes'.

Attached to the underside of the B777 landing gear are two metal containers usually referred to as 'Junction Boxes'. Among the functions of the 'junction boxes' is the control of various aspects of the wheel braking. Junction boxes are attached to the landing gear bogie by a series of metal straps (see figures 3 &4).

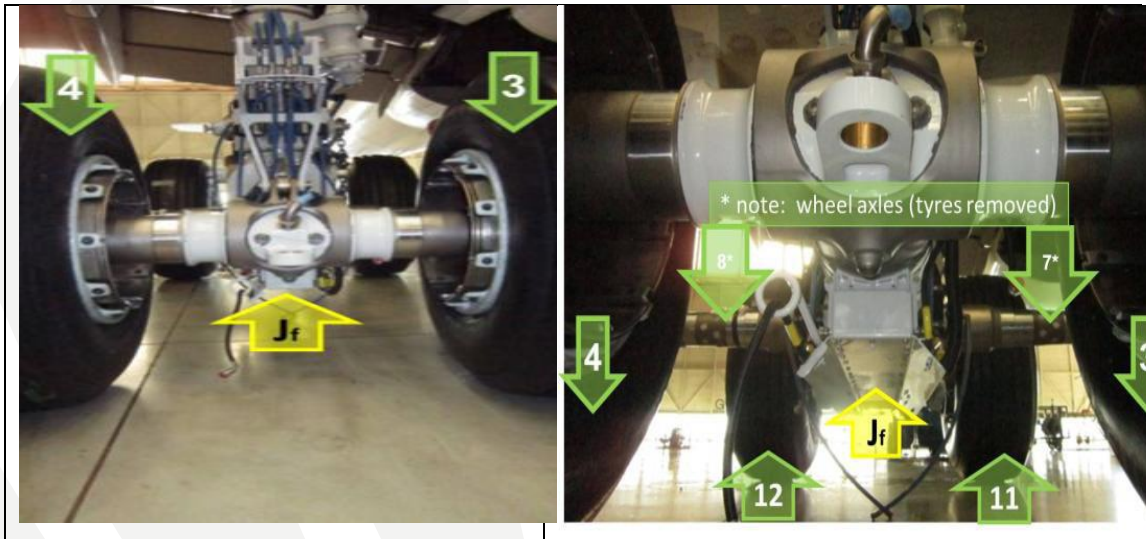


Figure 3. B777 landing gear junction box.

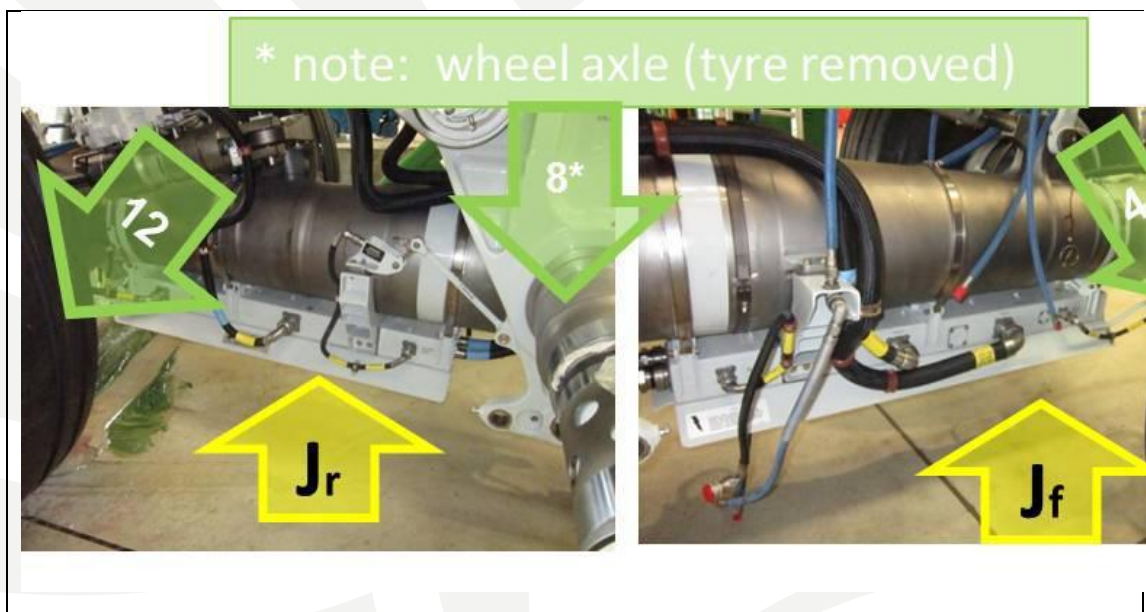


Figure 4. B777 landing gear Junction box side view.⁴

Loss or significant damage to the 'junction boxes' can lead to loss or degradation in braking including anti-skid control. The loss of anti-skid control can lead to tire skidding and associated frictional heating.

⁴ The photos are of the right gear but had a similar clamping method to that of the left gear. The centre wheels (#7 & #8) have been removed to provide a clearer picture of the attachments.

1.4 Other Damage

Parts of the runway surface showed damage with multiple grooves as a result of contact with the wheel hubs (see photos 29 & 30).



Photo 29. Damage on the runway surface.



Photo 30. Runway 18 threshold area showing the damage on the runway surface.

1.5 Personnel Information

The Commander and the first officer were current at the time of the incident and they were adequately rested before the incident flight.

	Commander	First Officer
Last 90 Days	207:23	197:32
Hours Flown in Last 28 Days	33:01	62:45
Hours Flown in Last 7 Days	5:35	16:28
Hours Flown in Last 24 Hours	5:35	5:35

Table 4. Crew members flying time the last 90, 28, 7 days and 24 hours.

1.6 Aircraft Information

The Boeing 777 is a long-range, wide-body twin-engine jet airliner manufactured by Boeing Commercial Airplanes.

The 777 is produced in two fuselage lengths. The original 777-200 model first entered service in 1995, followed by the extended-range 777-200ER in 1997; the stretched 777-300, which is 33.3 ft (10.1 m) longer, began service in 1998. The longer-range 777-300ER and 777-200LR variants entered service in 2004 and 2006, respectively.

The incident aircraft was a B-777-300 and didn't operate under any MEL restrictions that would influence the performance of the aircraft.

1.7 Meteorological Information

The crew reported that they were informed by the Tower that the runway was 'wet' with a tailwind of 8 knots. The QAR data indicated that the wind was 140° 3 knots at 1000 feet above airfield level (aal) on the final approach & 195° 11 knots at touchdown.

1.7.1 General Meteorological Situation at the destination airport (MLE).

Male lies in the Indian Ocean, just North of the equator at a latitude of approximately 4 degrees and at longitude approximately 73 degrees East. The overall weather patterns are tropical with two monsoon periods, the most active of which is around May to November.

1.7.2. Meteorological Reports on 2 Dec 11.

Local Time	UTC	Rainfall(mm)
0800	0300	NIL
1100	0600	NIL
1400	0900	NIL
1700	1200	NIL
2000	1500	3.3
2300	1800	9.2

Table 5. Rainfall before and at the time of the incident.

The following METARs and forecasts were made available before and after the incident aircraft landing:

SA 02/12/2011 23:30-> METAR VRMM NIL=
 SA 02/12/2011 23:05-> METAR VRMM NIL=
 SA 02/12/2011 23:00-> METAR VRMM 022300Z 21003KT 9999 FEW018TCU
 BKN260 27/25 Q1007 NOSIG=
 SA 02/12/2011 22:05-> METAR VRMM NIL=
 SA 02/12/2011 22:00-> METAR VRMM 022200Z 20004KT 9999 FEW018TCU
 BKN260 27/25 Q1007 NOSIG=
 SA 02/12/2011 21:30-> METAR VRMM NIL=
 SA 02/12/2011 21:05-> METAR VRMM NIL=
 SA 02/12/2011 21:00-> METAR VRMM 022100Z 20004KT 9999 FEW017TCU
 BKN260 27/25 Q1008 NOSIG=
 SA 02/12/2011 20:05-> METAR VRMM NIL=
 SA 02/12/2011 20:00-> METAR VRMM 022000Z 23004KT 9999 SCT017TCU
 BKN260 27/26 Q1008 TEMPO 5000 -SHRA=
 SA 02/12/2011 19:05-> METAR VRMM NIL=
 SA 02/12/2011 19:00-> METAR VRMM 021900Z VRB02KT 9999 FEW017TCU
 SCT120 26/25 Q1009 TEMPO 5000 -SHRA=
 SA 02/12/2011 18:05-> METAR VRMM NIL=
 SA 02/12/2011 18:00-> METAR VRMM 021800Z 23006KT 7000 -SHRA SCT017
 FEW018CB 26/25 Q1009 CB N,NE,E TEMPO 5000 -SHRA=
 SA 02/12/2011 17:05-> METAR VRMM NIL=
 SA 02/12/2011 17:00-> METAR VRMM 021700Z 05010KT 9000 -SHRA SCT017
 FEW018CB 27/25 Q1010 CB SW,NW TEMPO 5000 -SHRA=
 SA 02/12/2011 16:05-> METAR VRMM NIL=
 SA 02/12/2011 16:00-> METAR VRMM 021600Z VRB02KT 9999 FEW018 BKN120
 29/25 Q1009 NOSIG=
 SA 02/12/2011 15:05-> METAR VRMM NIL=
 SA 02/12/2011 15:00-> METAR VRMM 021500Z VRB02KT 9999 FEW017TCU
 BKN120 28/25 Q1009 NOSIG=
 FT 02/12/2011 23:00-> TAF VRMM 022300Z 0300/0406 02008KT 9999 FEW018
 SCT270 TEMPO 0300/0306 5000 -TSRA SCT017 FEW018CB SCT120=
 FT 02/12/2011 21:00-> TAF VRMM 022100Z NIL=
 FT 02/12/2011 17:00-> TAF VRMM 021700Z 0218/0324 02008KT 9999 FEW018
 SCT270 TEMPO 0219/0224 5000 -SHRA SCT017 FEW018CB SCT120=
 FT 02/12/2011 15:00-> TAF VRMM 021500Z NIL=

1.8 Aids to navigation

The airport was equipped with an ILS/DME, VOR/DME and NDB with RNAV approaches.

1.9 Communications

VHF communication with ATC was available.

1.10 Aerodrome Information

Male is in the Maldives at position 004°11'N 073°32'E. Male airport is at approximately sea-level elevation and consists of a single runway (airport datum position 004°11.5'N 073°31.8'E) which lies approximately 410NM SW of Colombo, Sri Lanka (see figure 5). The runway is orientated north-south (see figure 6). Construction of an asphalt runway began in 1964 with the runway was opened in April 1966. In recent times, during 2010, the airport runway was found to have some surface depressions which could lead to the retaining of water during rain storms. Further to the identified areas, asphalt repairs were carried out in Dec 2010 to correct surface undulations which resulted in standing water patches. The repair work was designed to provide a solution to the undulating areas for a period of time expected to be in excess of 15 months however undulations were identified earlier during 2011. The airport operator scheduled repairs for November 2011 but these were delayed due to prolonged periods of rainfall and were carried out between 18th to 26th Dec 2011.

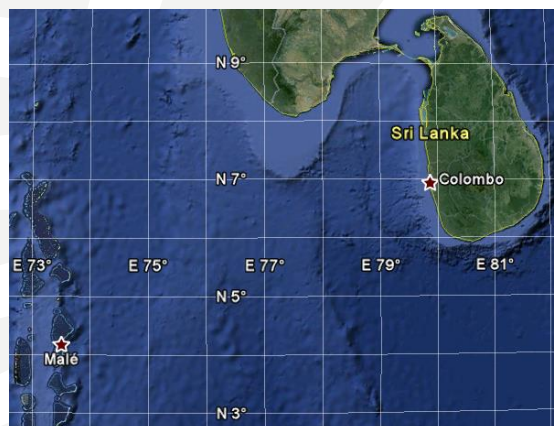


Figure 5. Google Earth image general location of Male Airport



Figure 6 Google Earth Image Male Airport, detail.

1.11 Flight Recorders

Both the CVR and DFDR were made available by the Airline for analysis.

1.7.1 DFDR.

The DFDR was made available to the GCAA.

1.7.2 CVR.

The CVR was made available but was not required for further analysis by the GCAA.

1.7.3 QAR.

QAR information was also retrieved and the data provided valid information.

1.12 Wreckage and impact information

There were no reported pertinent material failures and component malfunctions, prior to or during the occurrence.

Figure 7 shows the approximate positions of runway damage, the recovered junction boxes and the landing point.



Figure 7. Google Earth image with approximate position of the recovered junction boxes, runway damage and the landing point.

1.13 Medical and Pathological Information

The crew members involved in this event had valid medicals, were medically fit for the flight and didn't show any signs of fatigue.

1.14 Fire

There was no evidence of fire in flight or after the occurrence.

1.15 Survival aspects

For the purpose of this occurrence no search and rescue activity was required. Additionally, there was no evacuation performed.

1.16 Tests and Research

1.16.1 Junction Box Damage Analysis.

The manufacturer undertook an examination of all 6 band clamps from the 2 departed J-Boxes. See figure 3 for a photo of the recovered junction boxes. All of the failures were ductile failures, not attributable to fatigue. The failures were consistent with a failure mechanism of excessive standing water on the runway being splashed against the side of the junction boxes and likely overloading the band clamps (particularly the forward- and aft-most clamps).

1.16.2 Band Clamp Testing.

The aircraft manufacturer tested 10 new BACC10ET098T046E (most Fwd and Aft) band clamps. To develop a relationship between torque and band clamp performance, the aircraft manufacturer torqued the clamps to various values (range = 25 - 70 in-lbs) and applied a stepped vertical load at 200 lb increments until failure while measuring applied loads and displacement. To determine any difference in capability between the in-service and new clamps, the aircraft manufacturer used the same procedure on the clamps provided by the operator. To determine the torque required to break the clamp with no applied load, the aircraft manufacturer torqued a clamp until failure. The in-service clamps received from the operator failed within the same applied load range as the new clamps. BMT also examined the clamps and did not note any fatigue. The aircraft manufacturer band clamp lab testing revealed that band clamp failure load is unaffected by band clamp torque in the tested range. In summary, the results from the examination of all 6 band clamps from the 2 departed J-Boxes were that all of the failures were ductile failures, not attributable to fatigue. There was no specialized research performed for this investigation.

1.17 Organizational and management information

In 2010, a contract to operate MLE airport was awarded to a company 'GMR' who managed the airport until a legal dispute which saw the airport coming under the control of a Maldives Airports Company Ltd (MACL) in December 2012.

The Operator is an airline based in Dubai, United Arab Emirates. The airline is wholly owned by the Investment Corporation of Dubai. It is the largest airline in the Middle East Region, operating over 3,000 flights per week from its hub at Dubai International Airport, to more than 130 cities in 77 countries across the continents.



Photo 31. Recovered junction boxes from A6EMR.⁵

⁵ Forward and aft junction boxes at the top and bottom of the image respectively.

1.18 Additional Information

1.18.1 Hydroplaning⁶

Hydroplaning, also known as Aquaplaning⁷ is a condition in which standing water causes the moving wheel of an aircraft to lose contact with the surface on which it is load bearing with the result that braking action on the wheel is not effective in reducing the ground speed of the aircraft. When Hydroplaning occurs the tire cannot squeeze any more of the fluid contaminant layer between its treads and the tire lifts off the runway surface, thus losing its braking action efficiency.

Many organisations have performed considerable research and many publications provide valuable information for operating crew members. A 2005 National Aerospace Laboratory (Nationaal Lucht- en Ruimtevaartlaboratorium) study⁸ indicates that the runway condition is one of the factors influencing landing overruns, while a Flight Safety Foundation⁹ study underlines that flight crew members should obtain accurate and timely information on runway conditions. Runway conditions are not static; they may change in time with the change of environmental conditions, such as temperature and precipitation. That is why measuring and reporting runway conditions, which is the airport's responsibility, is important, while understanding the possible problems is the Operators responsibility to ensure that all crew members are familiar and ready to utilise all available information.

The same study reports that approximately 80% of runway excursion accidents that occurred in 1995 through March 2008 involved snow, slush or ice contaminated runways. Furthermore the study found that 11 approach-and-landing accidents and serious incidents involving runway overruns and runway excursions worldwide in 1984 through 1997, also involved wet runways.

1.18.2 Accidents due to wet runways / standing water

New York Runway overrun¹⁰

'On February 28, 1984 the first officer flying a DC-10 was making a manual CAT II ILS approach to Runway 04R at New York JFK airport. The captain noted that the airspeed was high and informed the first officer. The approach bug speed was 168 knots. However when the aircraft crossed the threshold the speed was 204 knots. The aircraft touched down about 4,700 ft. beyond the threshold of the 8,400 ft. runway and could not be stopped on the runway. The captain steered the aircraft to the right to avoid an approach light pier as it overran and it came to rest on the waters of Thurston Basin some 600 ft. beyond the end of the runway. The accident

⁶ Hydroplaning comes from the Greek word "νερό" Hydro which means water.

⁷ Aquaplaning, comes from the Latin word Aqua, which means water, which has an Indo-European route from the word Ak, which means bend, flex, curve, which has a Sanskrit route from the word Akna, which means curve, bend.

⁸ NLR-TP-2005-498, presented during the 58th annual International Air Safety Seminar (IASS), Moscow, Russia, 7-10 November, 2005 <http://www.nlr-atsi.nl/downloads/running-out-of-runway.pdf>.

⁹ ALAR TOOL KIT "Runway Condition Reporting", <http://www.skybrary.aero/bookshelf/books/1325.pdf>.

¹⁰ NTSB accident investigation report AAR-84/15

happened on a wet runway. The National Transport Safety Board NTSB determined that the probable cause of the accident was the crew's disregard for prescribed procedures for monitoring and controlling airspeed during the final stages of the approach, their decision to continue the landing rather than execute a missed approach and their over-reliance on the autothrottle speed control system, which had a history of recent malfunctions. The 163 passengers and 14 crewmembers evacuated the aircraft safely, but a few received minor injuries. The nose and lower forward fuselage sections, wing engines, flaps, and leading edge devices were substantially damaged at impact.'

Toronto overrun and fire A-340 accident¹¹

"The A340-313 aircraft (registration F-GLZQ, serial number 0289) departed Paris, France, at 1153 Coordinated Universal Time (UTC) as Air France Flight 358 on a scheduled flight to Toronto, Ontario, with 297 passengers and 12 crew members on board. Before departure, the flight crew members obtained their arrival weather forecast, which included the possibility of thunderstorms. While approaching Toronto, the flight crew members were advised of weather-related delays. On final approach, they were advised that the crew of an aircraft landing ahead of them had reported poor braking action, and Air France Flight 358's aircraft weather radar was displaying heavy precipitation encroaching on the runway from the northwest. At about 200 feet above the runway threshold, while on the instrument landing system approach to Runway 24L with autopilot and autothrust disconnected, the aircraft deviated above the glideslope and the groundspeed began to increase. The aircraft crossed the runway threshold about 40 feet above the glideslope. During the flare, the aircraft travelled through an area of heavy rain, and visual contact with the runway environment was significantly reduced. There were numerous lightning strikes occurring, particularly at the far end of the runway. The aircraft touched down about 3800 feet down the runway, reverse thrust was selected about 12.8 seconds after landing, and full reverse was selected 16.4 seconds after touchdown. The aircraft was not able to stop on the 9000-foot runway and departed the far end at a groundspeed of about 80 knots. The aircraft stopped in a ravine at 2002 UTC (1602 eastern daylight time) and caught fire. All passengers and crew members were able to evacuate the aircraft before the fire reached the escape routes. A total of 2 crew members and 10 passengers were seriously injured during the crash and the ensuing evacuation."

1.19 Useful or effective investigation techniques

No new, useful or effective investigation techniques have been used during this investigation.

¹¹ Transportation Safety Board of Canada Aviation Investigation Report Runway Overrun and Fire Report, Number A05H0002 <http://www.skybrary.aero/bookshelf/books/1040.pdf>

2 ANALYSIS

2.1 Crew Actions

The crew members were informed of the weather when approaching the destination airport, however they had no way of knowing the exact amount or location of standing water on the runway, as they assumed as per their training, that the runway was evenly wet. However the amount of water present on the runway during their landing was different to what they were expecting and it wasn't evenly distributed, as large amounts of water created different surface conditions ranging from wet to contaminated in different areas.

Crew members have to decide whether or not to divert or to enter the hold when weather conditions do not allow them to make a safe landing or if they need to verify their operating procedures when they are operating under MEL restrictions. However these conditions didn't apply to the incident flight, as the crew was not provided with any information that would have prompted them to divert, nor were they operating with any MEL operating restrictions. The tail wind reported did not impose any hazard and the landing was made in accordance with the Operator's training and procedures.

2.1. Male runway condition

The MLE airport runway surface has deteriorated over time leading to areas that allow water to pool. The general meteorological conditions to which MLE is subjected can lead to bursts of rainfall in certain months which raise the risks of water pooling occurring in a relatively short period of time. The monitoring of the runway conditions, remedial action to reduce the standing water hazard to an acceptable level and the communication of accurate runway condition reports to flight crew will reduce the risk of a similar event occurring in the future.

Previous accident investigation reports have recommended grooved runways and investing in modern runway friction measuring equipment to make landings safer. In addition Male Airport is exposed to a rainy season that may be considered a hazard to aviation. Study¹² performed in other, similar climates and countries, has shown that more than 45 per cent of landing accidents take place during the monsoon or in heavy rain. In addition the Flight Safety Foundation Approach and Landing Accident Reduction task forces¹³ first published work in 1998 indicated wet and contaminated runways as a major risk to runway related accidents. In addition, heavy rain may have a significant deteriorating effect on the runway condition, which should be factored in during any such runway re-surfacing, maintenance or re-construction. The

¹² Directorate-General of Civil Aviation (DGCA) study for India :
http://www.iasa.com.au/folders/Safety_Issues/RiskManagement/wet-runway-ops.html

¹³ Flight Safety Foundation : <http://flightsafety.org/current-safety-initiatives/approach-and-landing-accident-reduction-alar>

airport operator has to take every possible action in order to minimize the risks associated with the possibility of standing water.

All Operators flying into/out of and over Male airport should be aware of the runway surface condition and the consequent threats associated with operations there, until all efforts that the Investigation Team understands are in progress, produce results and enhance the runway safety. It is the responsibility of the individual Operator to assess the risks in order to provide a safe service. However the safety management system of Operators should be fed with the hazards.

2.2. B777 Junction Boxes

The metal straps which secure the junction boxes to the aircraft landing gear can be damaged by water impact. In some instances such as this event, detachment of junction boxes could occur. Since the incident event, the manufacturer has undertaken a review of the junction box attachment design and changes have been made to strengthen the securing straps. Junction boxes on B777 aircraft have previously suffered instances of damage.

3 CONCLUSIONS

3.1 Findings

3.1.1. The aircraft had no reported faults before landing, was insured and the maintenance records indicated that the aircraft was equipped and maintained in accordance with existing regulations and approved procedures. Furthermore, the flight crew members were appropriately licensed and qualified for the flight in accordance with existing regulations;

3.1.2. The runway had previously been identified as having areas which could lead to the retention of standing water.

3.1.3. Rain had begun to fall before 1500hrs UTC and continued to fall when the approach was made in rain at 1735hrs UTC.

3.1.4. No runway water removal activities took place between the time that rainfall began and before the time that the aircraft landed.

3.1.5. ATC reported to the crew the runway was 'wet' but provided no information concerning any areas of significant standing water.

3.1.6. The crew reported the approach and touchdown were 'normal' with the first indication of any abnormality occurring approximately halfway down the runway.

3.1.7. The junction boxes were found on the runway having detached from the aircraft during the landing rollout.

3.1.8. All of the junction box failures were ductile failures, not attributable to fatigue.

3.1.9. The junction box failures were consistent with excessive standing water on the runway being splashed against the side of the junction boxes and likely overloading the band clamps (particularly the forward- and aft-most clamps).

3.1.10. Damage to the left main landing gear tires and wheels occurred during the landing rolling.

3.1.11. The examination performed at the manufacturer shop showed no evidence of tire related discrepancies from the specification.

3.1.12. The manufacturer assessment was that the damage was related to a cause external to the tire.

3.2 Causes and Contributing factors

3.2.1 Male Airport Runway Condition leading to areas of standing water.

3.2.2 Information provided by ATC to the Crew concerning the status of the runway.

3.2.3 Lack of reduction of the areas of standing water on the runway to below a depth that posed a hazard to the aircraft.

3.2.4 The ability of the junction box securing straps to withstand the loads from the water encountered during the landing sequence.

4 SAFETY RECOMMENDATIONS

4.1 Safety Actions Taken.

The GCAA

The Airworthiness Sector undertaken activities to ensure that the resulted safety recommendation by this investigation related to the continued airworthiness of the aircraft will be properly followed up by all relevant operator. Additionally, there is an on-going task at every transit to inspect the Junction Boxes. Furthermore coordination is on-going to confirm the status of strengthening the Junction Box attachment Straps.

The Airport Operator.

The airport has stated that a combination of activities have been implemented including a runway repair programme, post-rain observations to detect areas of water pooling and procedures to clear water to allowable limits. Furthermore the airport operator stated that SOPs are now in place to report any runway contamination according to ICAO standards and recommendations.

The Aircraft Manufacturer.

The aircraft manufacturer is currently in the process of strengthening of the junction box attachment straps.

The Aircraft Operator.

The condition of the MLE runway has been an item on the Safety Board agenda of the operator of the incident flight and a number of visits of personnel from the operator and manufacturer have taken place to monitor the runway condition at MLE.

4.2 Safety Recommendations

SR 03/2014 To the GCAA:

GCAA should ensure that all UAE Operators utilising Male as a destination or/and as an en-route or destination alternate are aware of the results of this investigation.

SR 04/2014 To the Maldives Civil Aviation Authority

Until the runway enhancements are finalised the Maldives Civil Aviation Authority should ensure that Operators utilising Male airport are fully aware of the runway condition.

END