الهيئة العامة للطيران المدني
GENERAL CIVIL AVIATION AUTHORITY

United Arab Emirates

Air Accident Investigation Sector

Incident

- Final Report –

Nose Gear Tire Tread Separation on Takeoff

AAIS Case N° AIFN/0012/2010

Operator: Emirates
Type: Boeing 777
Registration: A6-EWC
Location: Dubai International Airport, U.A.E.
Date of Occurrence: 08 August 2010

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

Incident Brief

GCAA AAI Report No.:	AIFN/0012/2010
Operator:	Emirates
Aircraft Type and Registration:	Boeing 777 – 200LR, A6-EWC
Date and Time (UTC):	08 August 2010
Location:	Dubai International Airport, U.A.E.
Type of Flight:	Commercial, passenger
Injuries:	None

Investigation Objective

This Investigation is performed pursuant to the United Arab Emirates (UAE) Federal Act 20 of 1991, promulgating the Civil Aviation Law, Chapter VII, Aircraft Accidents, Article 48. It is in compliance with Part VI, Chapter 3 of the UAE Civil Aviation Regulations, in conformity with *Annex 13 to the Convention on International Civil Aviation* and in adherence to the *Air Accidents and Incidents Investigation Manual*.

The sole objective of this Investigation is to prevent aircraft accidents and incidents. It is not the purpose of this activity to apportion blame or liability.

Investigation Process

The occurrence involved a Boeing 777 – 200LR passenger Aircraft, registration A6-EWC, was notified to the General Civil Aviation Authority (GCAA) by phone call to the Duty Investigator (DI) Hotline Number +971 50 641 4667.

After the Initial/On-Site Investigation phase, the occurrence was classified as an 'Incident'.

An Investigation Team was formed in line with the Annex 13 obligations of the UAE being the State of Occurrence, Registry and the Operator.

The scope of the Investigation into this Incident is limited to the events leading up to the occurrence; no in-depth analysis of non-contributing factors was undertaken.

Notes:

[1] Whenever the following words are mentioned in this Report with the first letter Capitalized, it shall mean:

- (Aircraft) - the aircraft involved in this Incident.

- (Investigation) - the investigation into this Incident
- (Incident) - this investigated Incident
- (Report) - this Incident Report

2 Unless otherwise mentioned, all times in this Report are Coordinated Universal Time (UTC), (UAE Local Time minus 4).

3 In this Report, the word 'Cockpit' and 'Flight Deck' are synonyms.

4 Photos used in the text of this Report are taken from different sources and are adjusted from the original for the sole purpose to improve clarity of the Report. Modifications to images used in this Report are limited to cropping, magnification, file compression, or enhancement of color, brightness, contrast or insertion of text boxes, arrows or lines.

4 This Report is based on the field investigation performed by the GCAA IIC, the Operator's provided factual information and the Tire Inspection and Analysis Nose Tire Manufacturer's report, dated 24 November 2010.

Abbreviations and Definitions

AAIS	Air Accident Investigation Sector
AC	Augmenting Crew
ACP	Attendant Control Panel
ADIRS	Air Data Inertial Reference System
ADU	Air Data Unit
ADP	Annual Developing Plan
AEA	Association of European Airlines
AIFN	Accident/incident file number
AIU	Aircraft Interface Unit
AMU	Audio Management Unit
AOD	Airside Operation Directive of Dubai Airports
ARFFS	Aerodrome Rescue and Fire Fighting Services
ASDA	Accelerate Stop Distance Available
ASAG	Aerodrome Safety Action Group
ATPL	Airline Transport Pilot License
ATS	Air Traffic Service
CAAP	UAE GCAA Civil Aviation Advisory Publication
CARs	Civil Aviation Regulations
CCA	Circuit card assembly
CCM	Cockpit Crewmember
CM1	The pilot occupying the left hand seat in the cockpit
CoA	Certificate of Airworthiness
CoR	Certificate of Registration
CRM	Crew Resources Management
DFDAF	Digital Flight Acquisition Function
DI	Duty Investigator
D-SUB	Electrical connector
EICAS	Engine Indication and Crew Alerting System
FAA	Federal Aviation Administration
FOD	Foreign Object Debris
FMCS	Flight Management Computer System
GCAA	General Civil Aviation Authority of the United Arab Emirates

GSE	Ground Support Equipment
ICAO	The International Civil Aviation Organization
KPI	Key Performance Indicator
lbs	pounds
mm	millimetre
MSN	Manufacturer Serial Number
No.	Number
OC	Operating Crew
PA	Passengers Address
PF	Pilot Flying
PM	Pilot Monitoring
P/N	Part Number
QRH	Quick Reference Handbook
S/N	Serial Number
RST	Runway Safety Team
CVR	Cockpit voice recorder
FDR	Flight data recorder
SAGS	Safety Action Groups
SOP	Standard Operating Procedures
STC	Supplemental Type Certificate
UAE	The United Arab Emirates
USB	Universal Serial Bus
UTC	Coordinated Universal Time

Synopsis

On 08 August 2010, at 05:57 UTC, Emirates flight EK211, operated by a Boeing 777-200LR aircraft, registration A6-EWC, commenced its take-off roll from the full length of runway 12R at Dubai International Airport (DXB), with the Commander as pilot flying (PF). At a speed close to 170 knots, the PF rejected the take-off after hearing a loud noise and prior to accelerating through V_1 [1]. The Aircraft was stopped on the centerline of the runway and the airport fire service attended. There were no crew or passenger injuries reported.

The cause of the incident was identified to be a tread separation of the right hand nose wheel tire.

A contributing factor to the Incident was Foreign Object Debris (FOD)[2].

Safety Actions Taken:

The UAE General Civil Aviation Authority (GCAA) established the UAE National Runway Safety Team, along with an associated Safety Action Plan. This plan includes an FOD prevention program.

The Airport Operator took various Safety Actions and amended the Airport's FOD management including FOD training, campaigns, measurement, maintenance, cleaning and detection.

Safety Recommendation:

This report contains the following two safety recommendations:

The GCAA should review the possibility of enhancing the existing FOD prevention program.

The GCAA should ensure that all UAE aerodromes have established effective FOD awareness programs.

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[1] As Per CAR Part 1 Definitions, V_1 is defined as the maximum speed during take-off at which the pilot must take the first action to stop the aircraft within the accelerate-stop distance. V_1 also means the minimum speed in the take-off, following a failure of the critical engine at V_{EF}, at which the pilot can continue the take-off and achieve the required height above the take-off surface within the take-off distance (Issue 02 dated June 2014).
The same document defines V_{EF} as the speed at which the critical engine is assumed to fail during take-off.

[2] As per UAE GCAA CAR Part IX, Issue 3, revision 00 dated February 2014 Foreign Object Debris (FOD). Any debris on the airfield that can cause damage to an aircraft.
Foreign Object Debris or Foreign Object Damage (FOD) at airports includes any object found in an inappropriate location that, as a result of being in that location, can damage equipment or injure personnel.)

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1. Factual Information

1.1 History of the Flight

On 08 August 2010, at 05:57 UTC, a Boeing 777-200LR aircraft registration A6-EWC, operating Emirates flight number EK211from Dubai International, United Arab Emirates to Houston, United States of America, commenced its take-off roll from the full length of runway 12R, at Dubai International Airport, UAE, with the Commander as pilot flying (PF). The aircraft was 5,767 kilograms below the maximum certified take-off mass and had a correctly calculated decision speed (V_1) of 178 knots. At a speed of approximately 170 knots, the crew heard a loud bang and saw tire debris flying up in front of the aircraft, followed by significant vibration from the nose gear.

The PF rejected the take-off prior to V_1 and during the rejected take-off the Aircraft speed did not exceed V_1. The aircraft was stopped on the centerline of the runway, with ample paved surface remaining. ATC was notified and the airport fire service attended. The commander alerted the cabin crewmembers. Due to the high energy rejected take-off (RTO) an Engine Indication and Crew Alerting System (EICAS) warning for 'brake temperature' activated and the main gear tires deflated. The crew did not attempt to move the aircraft. They started the APU, and shut down the engines. The fire service reported smoke coming from the main gear area and cooled the brakes with water. The commander made a public address to the passengers, explaining that the take-off had been rejected due to a tire failure and that everyone would disembark via steps.

The disembarkation, of all the passengers, was completed 25 minutes after the event.

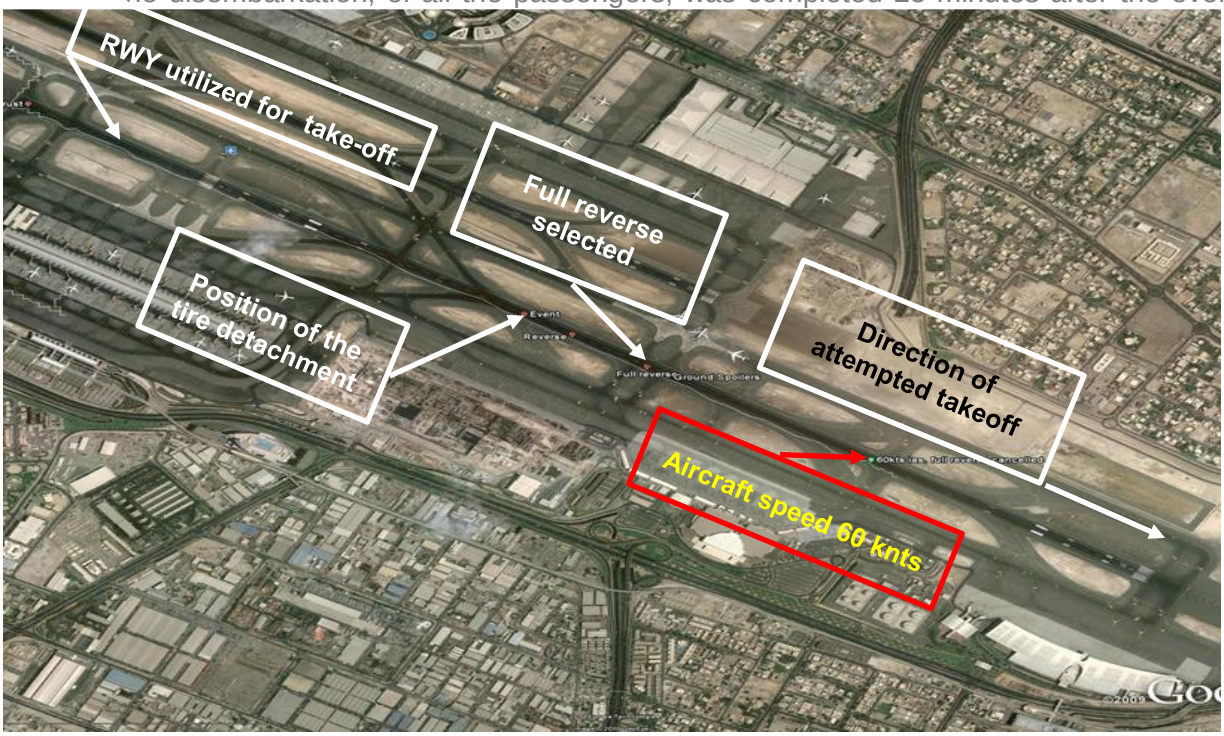

Figure 1. The event.

1.2 Injuries to Persons

Injuries	Flight Crew	Cabin Crew	Other Crew Onboard	Passengers	Total Onboard	Others
Fatal	0	0	0	0	0	0
Serious	0	0	0	0	0	0
Minor	0	0	0	0	0	0
None	4	14	0	269	287	0
TOTAL	**4**	**14**	**0**	**269**	**287**	**0**

Table 1. Injuries to persons

There were no injuries to persons as a result of the Incident.

1.3 Damage to Aircraft

Apart from tires and landing gear, damage to the aircraft was confined to several impact marks and dents on the underside of the fuselage aft of the nose gear, and rubber impact streaking forward of the nose gear bay and one of the nose gear landing lights was destroyed. Additionally, all of the main gear axles had to be replaced due to damage caused by deceleration forces and heating of the brake assemblies during and after the rejected take-off (RTO).

1.4 Other Damage

There was no damage to property or the environment.

1.5 Personnel Information

Table 2 illustrates the Operating Crew (OC) and the Augmenting crew (AC) information.

Crew information				
	Captain OC	**First Officer OC**	**Captain AC**	**First Officer AC**
License Category	ATPL	ATPL	ATPL	ATPL
Date of last medical	03 Mar 2010	25 Apr 2010	14 Jun 2010	16 Nov 2009
Date of last recurrent check	11 Feb 2010	03 Mar 2010	16 Feb 2010	03 May 2010
Flying Hours				
Total	10802	6851	10689	6655
Total on B777	6366.07	1736.48	2658.50	2167.52
Total within the company	6366.07	1736.48	4245.21	2167.52
Total last 28 days	29.50	69.23	47.18	48.54
Total last 7 days	20.03	21.62	5.36	5.36

Table 2. Operating and Augmenting Crew Information.

1.6 Aircraft Information

Incident Aircraft Information	
Aircraft type	Boeing 777 – 200LR
Manufacturer	Boeing
Serial number	35576
Year of manufacture	19 Nov 2007
Nationality	United Arab Emirates
Registration	A6-EWC
Cabin configuration	3 Class
Engine type	GE90-110B1L1
Certificate of Registration	Issued 19 Nov 2007
Certificate of Airworthiness	Issued 19 Nov 2007
Last 'A' maintenance check	16 Jul 2010

Table 3. Incident Aircraft Information.

1.6.1 Weight and Balance

The table below illustrates the weight and balance information for the flight;

Weight and Balance	
Maximum Take-off Mass	343.369 kg
Maximum Landing weight	223.167 kg
Zero fuel weight on flight plan	206.602 kg
Take-off weight on flight pan	337.602 kg
Landing weight on flight plan	216.802 kg

Table 4. Incident Weight and Balance Information.

1.6.2 Tire Information

The Table below illustrates information relevant to the damaged tire;

Wheel position RH Nose wheel
Size : 43x17.5R17
PR : 32
S/N : Z07LJ077
Manuf. Date: December 2007
Construction : Radial
Manufacturer : Bridgestone
Casing P/N : APR06600
Qualification : TSO-C62d
Rated Load : 44,500 lbs
AEA[3] Code : N06-B08
Remaining Skid : Approx. 6.5mm
Retread Level : R1
Date last retread : January 2010
Number of landings at time of incident : 54
Tire inflation pressure at time of incident : 229 psi

Table 5. Incident Right Hand Nose Wheel Information.

1.7 Meteorological Information

The prevailing meteorological conditions were not a factor in this Incident.

1.8 Aids to Navigation

None of the ground-based navigation aids, onboard navigation aids, or aerodrome visual ground aids and their serviceability were a factor in this Incident.

[3] Association of European Airlines

1.9 Communications

The quality of communication between the Aircraft and Dubai ATC was good.

The cabin-to-flight deck communication was made via the intercom system with good clarity and continuity.

1.10 Aerodrome Information

The airport fire and rescue services were placed on standby after the announcement by the crew that the take-off was being rejected. The fire and rescue services were not required to intervene, except to take action to cool the aircraft brakes following the high speed RTO.

1.11 Flight Recorders

The aircraft was equipped with three main recording devices:

- A flight data recorder (FDR)
- A cockpit voice recorder (CVR)
- A quick access recorder (QAR)

The FDR and CVR were mandatory equipment required for this Aircraft, as per UAE GCAA regulations.

The QAR is utilised by the operator for flight data and aircraft system monitoring activities. The aircraft flight parameters recorded by the QAR included most of the FDR parameters, with additional parameters as configured by the operator.

1.11.1 FDR system

The FDR fitted to A6-EWC was a DFDR (P/N AP41116101) manufactured by SAGEM SA (SFIM INDUSTRIES).

FDR specifications:

The Digital Flight Data Acquisition Function (DFDAF) receives all flight parameters, converts them to digital format and then sends them to the FDR, which records the data.

1.11.2 CVR System

The CVR installed on A6-EWC was manufactured by L3 Communication (P/N S200-0012-00).

When the aircraft electrical system is powered, and the cockpit voice recorder (CVR) circuit breaker is closed, the CVR operates continuously. The CVR records the last 120 minutes of cockpit audio and it was deactivated after the incident. Both the FDR and CVR were downloaded at the AAIS laboratory in Abu Dhabi. Both recorders contained correct data.

Time line of the event. Information retrieved from the on-board recorders. Distance from the end of RWY 12R is calculated; therefore should be considered approximate.		
Time (UTC) **(hh:mm:ss)**	**Event Description**	**Distance from RWY12R End (m) (Note: ASDA 12R = 4570m)**
05:34:00	Start of recording	N/A
05:36:08	Engines started	N/A
05:55:18	Aircraft lined up on runway 12R	4565
05:55:34	Thrust levers advanced from closed position	4565
05:55:40	Thrust stabilised at 55% N1	4556
05:55:43	TOGA thrust (100% N1)	4526
05:55:44	Aircraft computed airspeed (CAS) increases above 10 knots	4520
05:56:00	Aircraft computed airspeed (CAS) = 80 knots Groundspeed (GS) = 82 knots	4200
05:56:05	Aircraft computed airspeed (CAS) = 100 knots Groundspeed (GS) = 104 knots	3968
05:56:24	Vertical acceleration spike of 1.539G	2636
05:56:26	Movement of the Forward thrust levers from *TOGA* to *CLOSED* position (Action completed within 1 second)	2453
05:56:27	Speedbrake lever moved to the *UP* position	2350
05:56:27	Maximum recorded computed airspeed (CAS) = 176 knots Ground speed (GS) = 183 knots	
05:56:30	*Reverse thrust levers moved to the MAXIMUM REVERSE THRUST POSITION*	2167
05:56:30	Ground spoilers extended	
05:56:34	Maximum reverse thrust established (80% N1)	1780
05:56:41	Aircraft computed airspeed (CAS) = 60 knots Groundspeed (GS) = 79 knots	1319
05:56:41	Movement of reverse thrust levers from MAXIMUM REVERSE to REVERSE IDLE position	
05:56:50	Aircraft stopped	1216
06:00:39	EICAS 'brake temperature indication' and the first main gear tyre deflation by fuse plug	N/A

Table 6. Time line of the Rejected take-off.

1.12 Wreckage and Impact Information

As stated in sub-section 1.3 of this Report, the aircraft was undamaged, with the exception of the nose wheel tire, the impact marks and the dents on the underside of the fuselage.

1.13 Medical and Pathological Information

No medical or pathological investigations were conducted as a result of this Incident, nor were they required.

1.14 Fire

There was no indication of fire.

1.15 Survival Aspects

Not applicable.

1.16 Tests and Researches

1.16.1 Tire Inspection & Analysis Report

The failed tire was inspected in a laboratory and the tire outboard sidewall was found to be in a normal condition (see figure 2).

Figure 2. The failed tire outboard sidewall.

The inboard tire sidewall exhibited signs of seven large bulges in the upper sidewall/shoulder area (see figure 3).

Figure 3. Inboard sidewall.

The tread crown had fully detached from the casing, except for the outboard shoulder rib, which remained firmly attached to the casing.

The separation surface was located at the top surface of the first belt ply and the original under-tread rubber (see figures 4 & 5).

Figure 4. Separation Surface (overview).

Figure 5. Separation surface (detail).

The detachment pattern indicates good adhesion.

Approximately 50% of the detached tread pieces were recovered. Closer examination of the detached tread pieces highlighted the presence of a large notch, measuring 46mm x 17mm in the surface of the tread center rib rubber (see red circle in figure 6).

Figure 6. Indentation on the center rib.

On the corresponding surface underneath the large notch, a clear sign of separation was evidenced by the smooth aspect and blue coloration of the rubber resulting from heat build-up due to internal friction (see figures 7 & 8 in red circles).

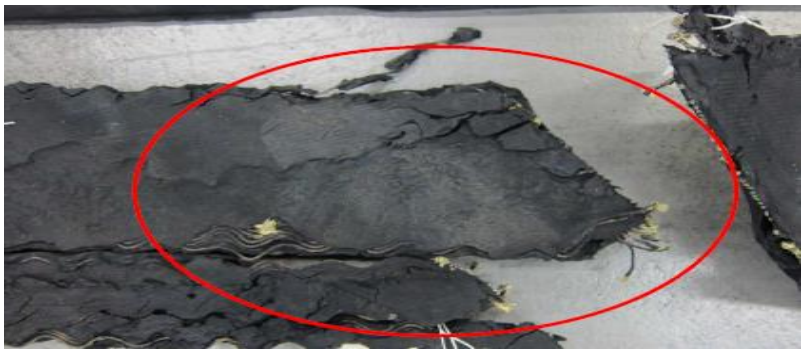

Figure 7. Blue coloration on the surface underneath of the detached area.

Figure 8. Heat buildup indications.

The investigation indicated that the casing plies showed no indication of separation or anomaly within the casing structure. The laboratory report concluded that the cause for the tire tread separation was an impact with a blunt foreign object.

1.16.2 UAE Database

Research of the UAE Mandatory Reporting Database of FOD[4] provided the following results, for all UAE airports, for the years from 2011 to 2014 (see figure 9).It should be noted that the presented numbers did not involve aircraft damage.

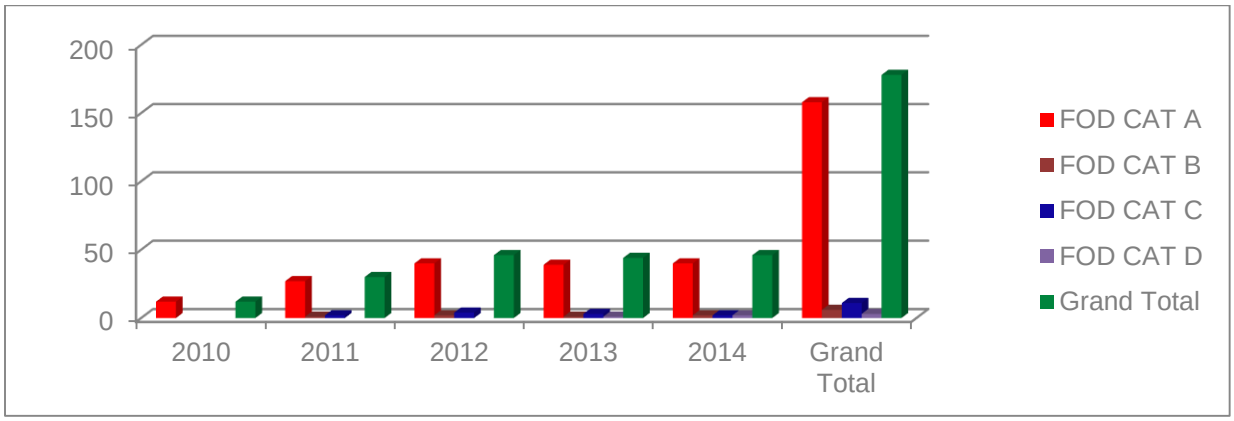

Figure 9. Number of FOD Related Events per Year all UAE Airports.

It must also be noted that in accordance with the UAE regulations the FOD Category A is the only category of FOD that is mandated to be reported. Category A is the FOD, which in accordance with the reporter, is likely to cause damage to an aircraft found on a runway or runway shoulder. Therefore, the figures indicate the mandatory reports along with few optional FOD reports, which are Categories B, C and D. Figure 9 must read with the above information in mind, as numbers do not represent all UAE FOD, but mainly the mandatory reportable FOD events reported in the UAE database.

[4] As per UAE GCAA CAR Part IX issue 03 revision 00 dated February 2014, CAAP 22, issue 04, revision 01 dated November 2014, CAAP 43 Foreign Object Debris (FOD) ,Original Issue, dated August 2010, an incident involving FOD detected on a runway including reported tire bursts from aircraft which have recently operated on a runway.
Category (CAT) A: FOD which is likely to cause damage to an aircraft on a runway or runway shoulder;
Category (CAT) B: FOD which is likely to cause damage to an aircraft found within runway strip or RESA;
Category (CAT) C: FOD which is likely to cause damage to an aircraft on taxiways or taxiway shoulders;
Category (CAT) D: FOD which is likely to cause damage to an aircraft found on the taxiway strips, apron areas or elsewhere on the airfield;

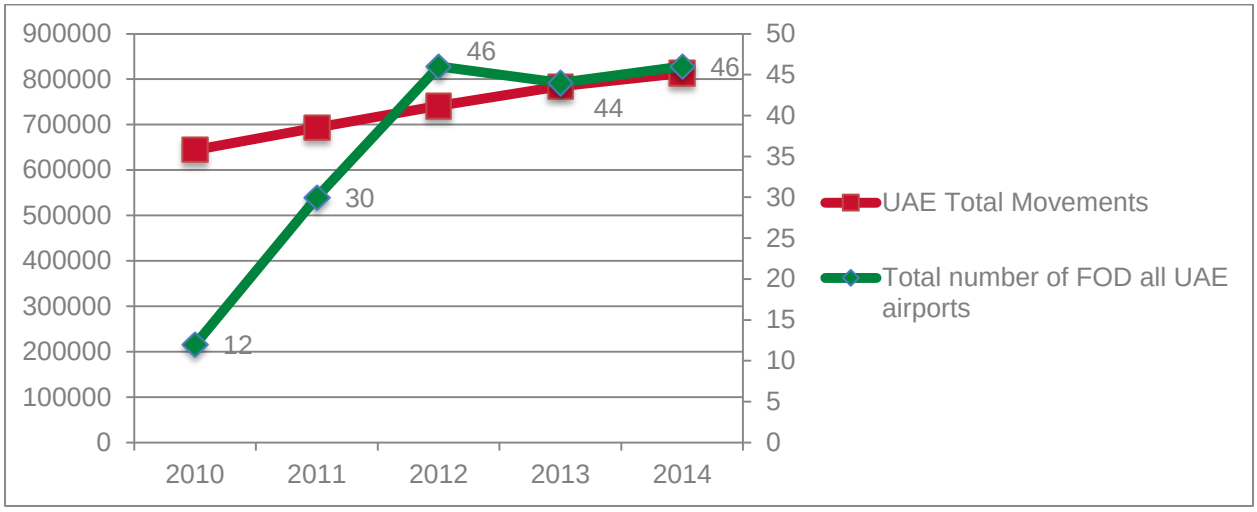

Figure 10. UAE Total Number of Movements versus Total Number of FOD all UAE Airports.

Figure 10 indicates the total number of movements in all UAE airports along with the total number of FODs recorded in the UAE database.
In figure 11, there is an indication of the number movements per FOD (green line). In addition a "two year moving average" is inserted (red line), which indicates that the rate of movements per FOD event has almost remained constant the last 3 years. In addition, it should be noted that the first two years of gathering data, the FOD number was small, as awareness was generated between and among the participating entities. Due to the small number of reports the number of movements per FOD was initially high.

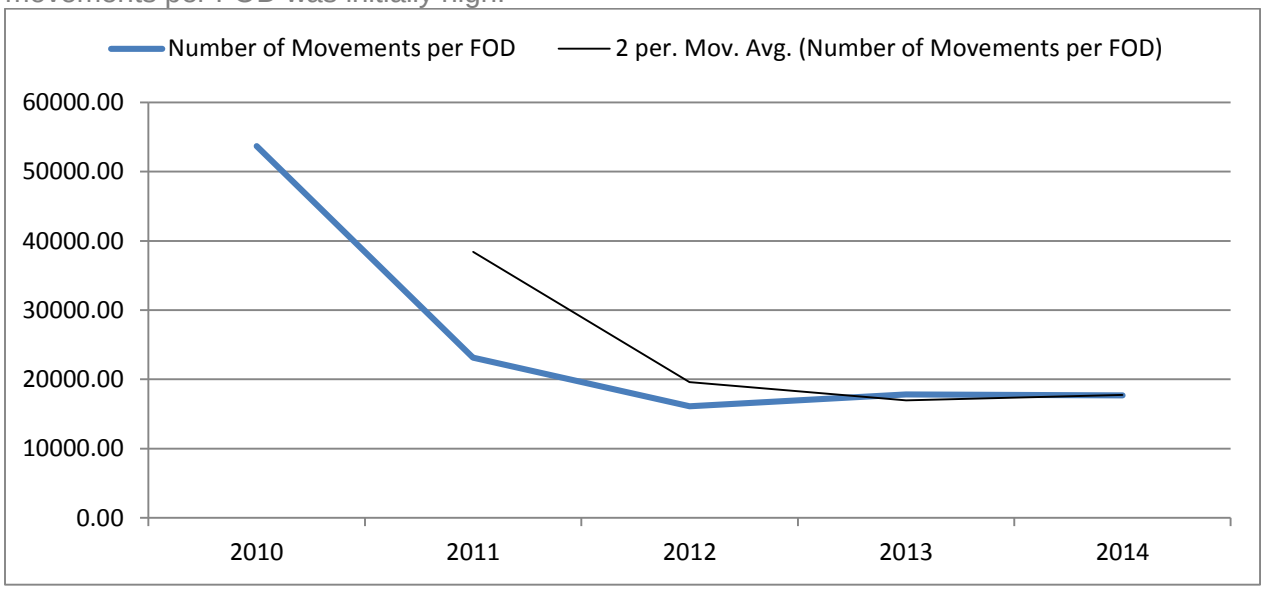

Figure 11. Number of Movements per FOD Event.

1.17 Organisational and Management Information

1.17.1 The Aircraft Operator

Emirates is based in Dubai, UAE, and operated a fleet of Boeing and Airbus wide body aircraft for both passenger and cargo services. The airline was one the world's largest Boeing 777 operators. The Operator held an Air Operators Certificate, issued by the GCAA, which provided regulatory safety oversight.

1.17.2 The Aerodrome Operator

The Aerodrome was owned and operated by Dubai Airports Company.

Dubai Airport has two runways, 12R/30L is 4,450 m × 60 m (14,600 ft × 200 ft), 12L/30R is 4,000 m × 60 m (13,120 ft × 200 ft). The runways are equipped with ILS.

Dubai international airport ranked as the fourth busiest airport in the world with international traffic of 50.98 million passengers in 2011. In the same year the airport had more than 325,000 aircraft movements and a cargo throughput of over 2.19 million tons. In addition, the airport encompassed cargo facilities area of 35,000 sq. meters. The airport was linked by three general service roads. At the time of the incident, it was estimated that approximately 2000 vehicles belonging to the airport and its stakeholders operated airside on a daily basis.

The airport management recognized the FOD risk that the large number of movements of vehicles and aircraft posed and accordingly various measures were put in place, after the occurrence to mitigate and monitor the FOD hazard. These measures included training of personnel, visual inspection of operational areas, and FOD reduction programs and maintenance.

1.18 Additional Information

1.18.1 UAE GCAA Regulatory Framework

1. Publication of *Civil Aviation Advisory Publication - CAAP 43 – Foreign Object Debris* in August 2010 with the following objectives:
   a) guidance to Aerodrome Operators as to what should be included in their policy and procedures to prevent unacceptable levels of FOD.
   b) guidance to aerodrome users as to how they may contribute to more effective FOD control to ensure a safe aircraft operating environment
2. Publication of *Civil Aviation Advisory Publication - CAAP 36 – Runway and Movement Area Inspections* in February 2010 with the following purposes:
   a) guidance to Aerodrome Operators when undertaking runway and manoeuvring area inspections by describing the key elements of the inspection procedures
   b) guidance to aerodrome operators as to how they may vary the frequency of runway assessments in order to adjust maintenance schedules to meet the objective of adequate runway conditions for safe aircraft operations

3. GCAA Regulation CAR-PART IX[5] provided guidance to ensure Runway Incursion Prevention and FOD are a standing agenda item of the Safety Action Groups (SAGS) of all GCAA Certified Aerodromes.

1.18.2 Civil Aviation Authorities Foreign Object Debris

Several Civil Aviation Authorities have issued guidance for FOD prevention programs.

For example, the United States of America Federal Aviation Administration (FAA) has a Foreign Object Debris Program[6]

As defined in AC 150/5210-24, Foreign Object Debris (FOD) Management, "*FOD is any object, live or not, located in an inappropriate location in the airport environment that has the capacity to injure airport or air carrier personnel and damage aircraft*".

1.18.3 Efforts to prevent FOD

Worldwide, efforts were undertaken in order to enhance the knowledge and awareness of FOD and the potential associated damage. The national aerospace FOD prevention[7] has published an FOD prevention guideline[8], which provides "guideline for the military and commercial industry to prevent foreign object damage (FOD) to aerospace products being designed, developed, manufactured, assembled, operated, repaired, modified, refurbished and maintained"[9].

In addition many organizations and corporations are dedicated in providing equipment, such as magnetic sweeper bars, tow sweepers, walk behind sweepers, specialized cans and know-how in FOD prevention programs.

1.18.4 Rejected Take-off Studies

Boeing[10] indicates that the RTO maneuver has been a fact of a pilot's life since the beginning of aviation. Each takeoff includes the possibility of an RTO and a subsequent series of problems resulting from the actions taken during the reject. Historically, the RTO maneuver occurs approximately once each 3,000 takeoffs. Because the industry now acknowledges that many

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[5] CAR Part IX (Issue3) Chapter 4 item 4.16.5, Temporary revision 01/2014, issue date 11 August 2014, effective date 13 November 2014, downloaded 7 May 2015, from : https://www.gcaa.gov.ae/en/ePublication/_layouts/GCAA/ePublication/DownloadFile.aspx?Un=/en/epublication/admin/Library Pdf/Civil Aviation Regulations (CARs)/CAR Part IX - CIVIL AVIATION REGULATIONS - AERODROMES (CORRECTED) TR no.01.pdf

[6] Downloaded from http://www.faa.gov/airports/airport_safety/fod/ (dated 8 January 2015)

[7] National Aerospace FOD Prevention, Inc. (NAFPI) is a nonprofit, educational organization developed to standardize terms and methods for the prevention of foreign object damage to aircraft and aerospace vehicles, in the USA.

[8] Downloaded from: http://www.nafpi.com/nafpiguideline.pdf (dated 8 January 2015)

[9] NAFPI FOD prevention guideline page 3.

[10] Downloaded from: http://www.boeing.com/commercial/aeromagazine/aero_11/takeoff_story.html, dated 18 January 2015.

RTOs are not reported, however, the actual number may be estimated at 1 in 2,000 takeoffs. For example, an unreported RTO may occur when a takeoff is stopped very early in the takeoff roll because the flight crew hears a takeoff warning horn, stops to reset trim, then taxis back to the runway and continues takeoff. Many operators have a policy that, depending on the cause of the low speed RTO it is not necessary for the crew to report the RTO

Boeing study indicate that approximately 75 percent of RTOs are initiated at speeds less than 80 kt and rarely result in an accident. About 2 percent occur at speeds in excess of 120 kt. The overruns and incidents that occur invariably stem from these high-speed events.

A takeoff may be rejected for a variety of reasons, including engine failure, activation of the takeoff warning horn, direction from air traffic control (ATC), blown tires, or system warnings. In contrast, the large number of takeoffs that continue successfully with indications of airplane system problems, such as master caution lights or blown tires, are rarely reported outside the airline's own information system. These takeoffs may result in diversions or delays, but the landings are usually uneventful. In fact, in about 55 percent of RTOs the result might have been an uneventful landing if the take-off had been continued, as stated in the Takeoff Safety Training Aid published in 1992 with the endorsement of the U.S. Federal Aviation Administration (FAA).

Some of the lessons learned from studying RTO accidents and incidents include the following:

•More than half the RTO accidents and incidents reported in the past 30 years were initiated from a speed in excess of V_1.

•About one-third were reported as occurring on runways that were wet or contaminated with snow or ice.

•Only slightly more than one-fourth of the accidents and incidents actually involved any loss of engine thrust.

•Nearly one-fourth of the accidents and incidents were the result of wheel or tire failures.

•Approximately 80 percent of the overrun events were potentially avoidable by following appropriate operational practices.

1.18.5 Accident and Incident Reports.

An Airbus A-310, registration S2-ADE, owned and operated by Bangladesh Biman Corporation Ltd, operating on a scheduled passenger flight from London United Kingdom to Dacca Bangladesh, with a stopover at Dubai International airport at 12 March 2007. During its take off from Dubai International runway 12L, passed V_1, the Commander rejected take-off after the crew heard a loud bang associated with considerable airframe shudder and vibration, later attributed to the collapse of the nose landing gear. The accident aircraft was kept under control and brought to a stop within the runway surface, left of the runway centerline.

Figure 12. The A-310, following the Collapse of the Nose Landing Gear, after hitting an FOD on the take-off runway.

The cause of the accident was indentified by the GCAA Air Accident Investigation team, as the collapse of the nose wheel landing gear, when it impacted a half wheel rim, which was broken off during the take-off roll of a previous aircraft (see below figure).

Figure 13. The Piece of the Wheel Rim, which was the cause of the Nose Landing Gear Collapse.

More occurrences are described in Appendix C.

1.18.6 The Operator's Rejected Take off procedures

The Operator has procedures in place giving the commander sole responsibility for the decision to reject the takeoff by clearly announcing the word STOP, before commencing the stopping action and assuming control of the aircraft in cases when the first officer performs the take-off. In this case, the Commander should keep his hand on the throttles (thrust levers) until V_1. In addition, above 80knots, and prior to V_1, the take-off should be rejected for any of the following reasons:

- Fire or fire warning

- Engine failure
- Predictive wind shear warning and
- If the airplane is unsafe or unable to fly.

The Operator states that the "*basic policy is to be "*go-minded", unless the stopping actions can be initiated before V_1"[11].

1.19 Useful or Effective Investigation Techniques

No new investigation techniques were used during this Investigation.

2. Analysis

Factors taken into consideration in the Investigation and discussed in the analysis are the FOD event and the commander's decision to reject the take-off.

2.1 Foreign Object Debris

Following an analysis of the right hand nose wheel tire debris, and the tire inspection report, it is evident that there was an imprint of an object that the failed tire had most probably passed over. The presence of this object, which the tire imprint showed did not have sharp edges or corners, was most likely, the initiating cause of the event. The object was not recovered. Therefore, it was not possible to determine where or when the tire ran over the object. But as the failed casing of the tire had marks of heat, one could argue of how many seconds it takes to generate the heat that was caused by the friction of the casing.

It is possible that the object was on the taxi route of the aircraft to the runway, or was most probably on the runway itself. Alternatively, the object could have been "picked-up" by the tire on an earlier occasion. The object caused a deep indentation in the tire and damaged it. This led to the separation of the tire tread during the takeoff roll and the tire pieces were thrown against the underside of the forward fuselage producing a loud banging noise, which was heard in the cockpit. This loud noise created an impression among the pilots that the Aircraft was unable or unsafe to fly. The Commander decided to stop the Aircraft on the runway by executing a high speed RTO.

Foreign Object Damage has been the cause of major accidents with the more known one to be the Concord, which caused a major catastrophe after take-off from Paris, killing all occupants and persons on the ground (see more in paragraph 1.18.7 Other Accident and Incident Reports, of this report). Furthermore these figures should be read having in mind that UAE regulations mandate the reporting of Category A FODs. These are the FODs that could cause damage to

[11] Operators Manual Part A paragraph 8.3.0.4.4.1.

aircraft. Therefore someone may interpret the figures as inaccurate and disproportionate amount of Category A against the other categories. But the GCAA database has Category A FODs mainly, with all other Categories being optional to report, therefore someone should not rightfully expect airport operators to report to the national database minor issues that they have no potential of damage to aircraft. The reporting of FOD itself is evidence of a thorough and effectively implemented inspection regime and the reporting culture developed (as required by UAE regulations).

Dubai airport had, at the time of the Incident, an FOD prevention program in place, which was enhanced, after the event (see more details in Appendix B). In addition, the runway FOD detection radar, which is currently being installed[12], will complement the FOD prevention effort. Dubai airports has created a visible FOD prevention program and has engaged as many stakeholders as possible. Nevertheless these efforts are on-going and need to be continuous as newcomers will always need to embrace the culture of FOD free maneuvering areas, if possible. Similar efforts, depending on the movement numbers and risks involved, such as nearby construction or moving assets that may create FOD, were undertaken in other UAE airports.

FOD was always considered a hazard in civil aviation. That is why the UAE National Runway Safety Team has identified the FOD prevention program, as one of its priorities. However other, more life threatening issues, such as Runway Incursions, were addressed in a National Level, the last few years. Although within the boundaries of this investigation a national survey wasn't performed to better understand the FOD issue, a research on the UAE Safety Database[13] revealed (see more in paragraph 1.16.2 of this report) the frequency of the events do not warrant an immediate action. However the moving average (see red line of figure 11) indicates that the rate of movements per FOD reported in the UAE Safety Database has remained constant the last two years. That is why actions have to be initiated nationwide in order to try to reduce the number of FODs created within the airports of UAE. Nevertheless, the appropriate instrument to take such a decision within the UAE is the Safety Affairs Air Navigation and Aerodromes department along with its stakeholders through the vehicle of the UAE National Runway Safety Team. That is why a decision should be made in order to review the possibility of initiating efforts within all UAE airports regarding the FOD issue. Furthermore this level of expertise could recognize if there is a need and what level of resources should be devoted in such an effort.

2.2 The decision to reject the take-off.

The RTO is a maneuver that all pilots are trained for. Historically the RTO maneuver occurs approximately once every 3000 take-offs.

In the event of a malfunction, the recognition of a significant abnormality, or an ATC instruction to stop the aircraft during the take-off roll, the crew will be able to safely reject the take-off, if the decision to do so is made at a speed not greater than the correctly calculated decision speed (V_1).

[12] The FOD detection radar is expected to become operational the first quarter of 2016. Date of the report June 2015
[13] ROSI AOP and ATC FOD data years 2010- 2014.

A successful RTO will result if the crew response is immediate, and is completed in accordance with prescribed Standard Operating Procedures (SOP).

The fact is that there are different ways to fly an airplane. However the reason behind the trend toward having and following standard procedures is mainly related to the constraint of flying with varying crews. SOPs are important to prevent the first officer from falling a phase behind the commander and if he or she does not know what action to expect from the other pilot, he or she may not have the time to learn it and adjust to it. As all aspects of flight work require a maximum amount of coordination and harmony among the crew it is vital to have and follow SOP in order for both pilots to know what to expect from the other cockpit crew member.

The Operator's SOP called for the Commander to decide, and to perform all RTOs. Although the decision to "STOP" was taken at high speed both crew members coordinated their actions and accomplished a successful RTO, which was performed in accordance with the Operator's SOPs. Therefore the successful rejection of take-off from V_1 was achievable in all but exceptional and very specific cases, it is universally recognized that the closer the speed gets to it, the greater the risk involved in a decision to stop. That is why, once at high speed, it is usually specified that the takeoff will only be rejected for major malfunctions such as an engine failure or fire - or at the discretion of the pilot in command in the event that a similarly serious situation is perceived, when the aircraft is unable to fly.

A tire failure during the take-off roll could lead to an inappropriate decision to reject a take-off. This was not the case in the Incident under investigation. It is generally known that failure of a tire will result in a longer than calculated stopping distance due to the loss of braking force on the associated wheel. But the nose wheel tire, which failed in this case, is not used for braking. However, it has the potential to lead to additional tire failure due to the high energy and the associated temperatures generated during a high speed RTO. During the Incident the other tire remained intact and the actual tire that threw a tread remained inflated. Nevertheless as the tire pieces were separated they were impacting the fuselage and other areas of the Aircraft. The impact created loud noises and bangs. Due to these bangs the Commander was under the impression that the aircraft was unsafe or unable to fly, and he performed the RTO at a speed below V_1. After initiating the STOP actions the speed initially continued to increase due to the momentum of the Aircraft .The speed of the Aircraft then started to decrease and the maximum speed recorded was below the V_1 speed. The Aircraft stopped 1216 m before end of runway, without any significant damage, other than that described in paragraph 1.4 of this Report.

3. Conclusions

3.1 General

From the evidence available, the following findings, causes and contributing factors were made with respect to this Incident. These shall not be read as apportioning blame or liability to any particular organisation or individual.

To serve the objective of this Investigation, the following sections are included in the 'Conclusions' section:

- **Findings-** are statements of all significant conditions, events or circumstances in this Incident. The findings are significant steps in this Incident sequence but they are not always causal or indicate deficiencies.
- **Causes-** are actions, omissions, events, conditions, or a combination thereof, which led to this Incident.
- **Contributing factors-** are actions, omissions, events, conditions, or a combination thereof, which, if eliminated, avoided or absent, would have reduced the probability of the Incident occurring, or mitigated the severity of the consequences of the Incident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil or criminal liability.

3.2 Findings

i. The flight crewmembers were licensed and medically fit, qualified and adequately rested to operate the flight.
ii. The Aircraft was airworthy when dispatched for the flight.
iii. During the take-off roll, the right hand nose wheel tire tread became detached.
iv. During the take-off roll, the commander decided to reject the take-off.
v. The RTO was initiated below the V_1 decision speed.
vi. The maximum speed reached during this high speed RTO was below the V_1 speed.
vii. Airport personnel recovered approximately 50% of the detached tire tread pieces.
viii. Examination of the detached tread pieces showed the presence of an indentation (46mm x 17mm) in the surface of the tread center rib rubber.
ix. No separation or anomaly could be detected within the tire casing structure.
x. The detachment of the tread was due to an FOD event that occurred at a time and place unknown.
xi. The Airport Operator had an FOD program that was enhanced, after the event.
xii. The UAE GCAA has established a UAE National Runway Safety Team.
xiii. The UAE National Runway Safety Team has established a Safety Action Plan.
xiv. One of the provisions of the UAE National Runway Safety Team, Safety Action Plan is FOD prevention.
xv. The FOD prevention provision of the UAE National Runway Safety Runway Team has been developed but not yet fully deployed and implemented.

3.3 Causes

The Air Accident Investigation Sector (AAIS) determines that the cause of the event is identified to be a tire tread separation of the right hand nose wheel tire.

3.4 Contributing Factors to the Incident

The tire had sustained damage due to FOD.

4. Safety Recommendations

4.1 General

The safety recommendations listed in this Report are proposed according to paragraph 6.8 of *Annex 13 to the Convention on International Civil Aviation*[14], and are based on the conclusions listed in section 3 of this Report; the General Civil Aviation Authority (GCAA) expects that all safety issues identified by the Investigation are addressed by the receiving States and organizations.

4.2 Safety Actions Taken

The Airport Operator enhanced the existing FOD prevention program, which included the purchase an installation of iFerret, runway FOD detection radar along with other activities, which are described in Appendix B.

4.3 Final Report Safety Recommendations

4.3.1 To The GCAA

SR 39/2015

The GCAA should consider activating an enhanced UAE FOD prevention program.

SR 40/2015

The GCAA should ensure that all UAE aerodromes have established effective FOD programs.

[14] Paragraph 6.8 of *Annex 13 to the Convention on International Civil Aviation* states: "At any stage of the investigation of an accident or incident, the accident or incident investigation authority of the State conducting the investigation shall recommend in a dated transmittal correspondence to the appropriate authorities, including those in other States, any preventive action that it considers necessary to be taken promptly to enhance aviation safety."

APPENDIX A

UAE National Runway Safety Team

Background Information

The UAE National Runway Safety Team was established in November 2012 with the support from GCAA's HE Director General, Executive Director Aviation Safety Affairs Sector and Director, Air Navigation and Aerodromes Department and support from all UAE certified Aerodromes and National Carriers in order to further runway safety initiatives related in support of local, national and ICAO safety frameworks, the ICAO Middle East Regional Aviation Safety Group initiatives and the implementation of the Global Aviation Safety Plan (GASP) and the associated Global Aviation Safety Roadmap (GASR) in the MID Region.

Purpose

The UAE National Runway Safety Team was created in order to strengthen communication and coordination within industry in order to support and develop local aerodrome runway safety teams and provide a national-level strategic framework to identify, prioritise and implement runway safety initiatives based on data analysis and international best practices in order to ensure continued and improved runway safety within the UAE.

Objectives

The Objectives of the National Runway Safety Team is to:

- support local runway safety teams and action groups at each UAE certified aerodrome;
- establish framework for identification, prioritisation and implementation of national runway safety initiatives;
- support the UAE State Safety Programme;
- analyse runway safety information and hazards to civil aviation at the national level and review the supporting action plans;
- facilitate the sharing of safety information and experiences among all stakeholders;
- reduce duplication of efforts by encouraging collaboration, cooperation and resource sharing;
- coordinate with existing GCAA Technical Committees on runway safety issues; and
- prepare, promote and conduct (if needed) industry runway safety training, awareness and promotional events.

UAE National Runway Safety Team Safety Plan 2014 – 2016

In accordance with the national runway safety team safety plan for the years 2014 to 2016 FOD has been identified as one of the areas that the team has initiated efforts following the increase in amount of reports regarding FOD found on runways or runway shoulders. Furthermore the Safety Plan 2014 – 2016 has recommendations scheduled for the 2015 and 2016 regarding FOD.

APPENDIX B

The Investigation Team was informed by the Airport Operator that various actions were taken in order to reduce the FOD. These actions are summarised below:

Purchase and installation of iFerret, an FOD detection system, which is expected to become operational the 1st Quarter of 2016; this FOD radar is based on sensors and is capable of detecting FOD on the runway with the following anticipating performance:

- Probability of FOD Detection: better than 90%
- Minimum FOD object size (under normal operation): A spherical item with 4 cm diameter or a cylinder measuring 3.1 cm high and 3.8 cm in diameter
- FOD Location Accuracy: +/- 1 m (average)
- Time-to-Detect FOD: The average detection time is as follows:
  - ✓ Within 90 seconds (average) for day time.
  - ✓ Within 150 seconds (average) for night time.
- Time-to-Promote-to-Alarm: Within 5 seconds (Average)

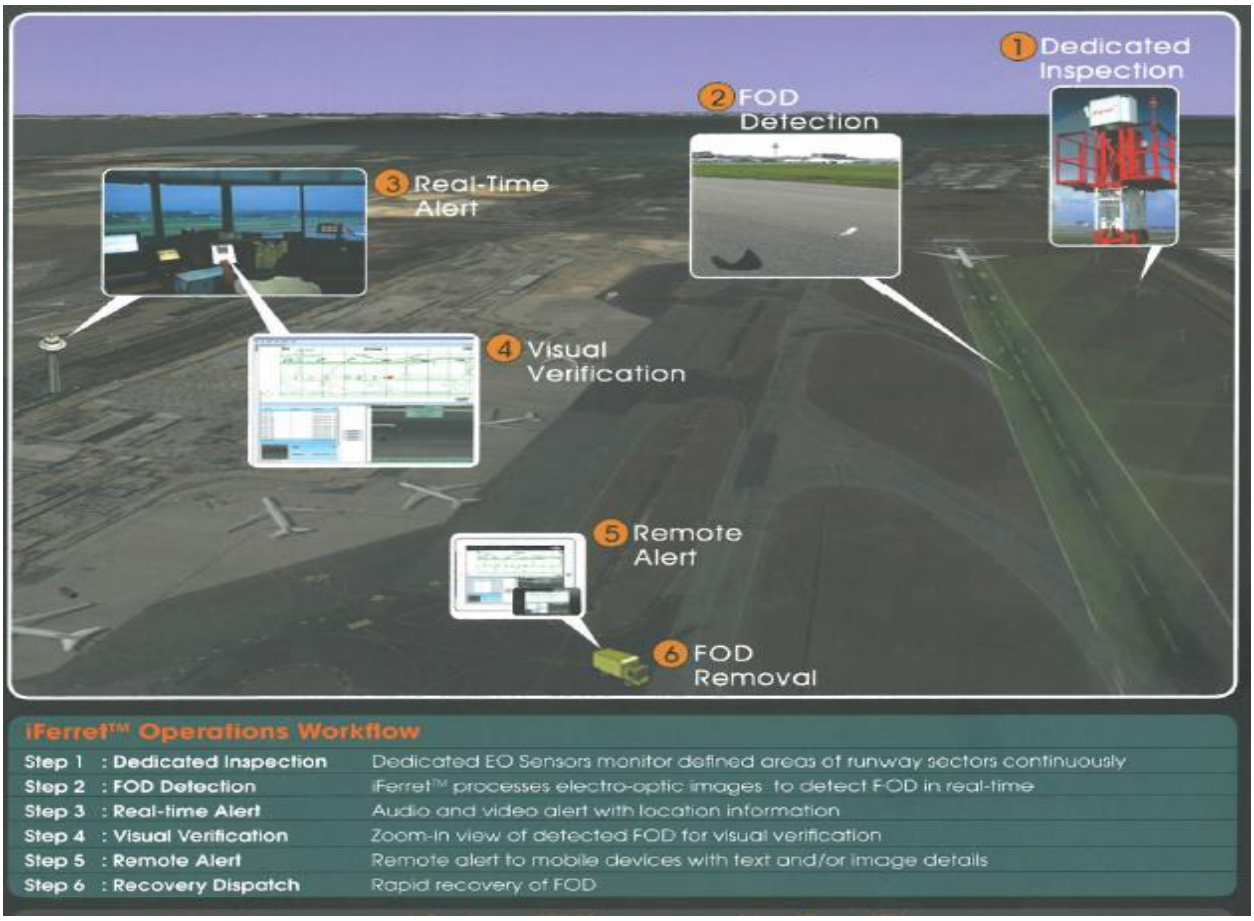

Figure 14. iFerret Operations Workflow.

A system of three tier inspection of the Maneuvering areas

- CAR PARTIX stipulates that the aerodrome movement areas are required to be inspected twice as a minimum in a 24 hour period.
- As against a planned number of 1650 inspections of the movement areas in a month, DXB exceeds this figure by more than double.
- Tier three is carried out once every six months by senior Management team. Aerodrome Safety Action Group (ASAG) members were also involved in the runway inspections.

Cleaning schedule of GSE roads

- Systematic cleaning carried out by Contractor (Facility care team) using sweeper machine, club car and pickups.
- Manual cleaning in critical areas.

Cleaning schedules in runways/taxiways and aprons

- Schedule in 2011 involved bimonthly cleaning of runways, taxiways and aprons are done by Engineering Services airfield civil works using FOD BOSS and FOD sweeper machines.
    - At the time of the report's publication[15] the cleaning schedule involved weekly cleaning of runways, bimonthly cleaning of taxiways, twice daily cleaning of taxiway crossings, seven weekly cleaning of bays.
- Manual cleaning staff positioned in baggage handling areas and aprons

Regular Stake holders Meeting

- Regular meetings (ASAG/RST) at varied levels are conducted with the stake holders at the airport and issues pertaining to FOD's are discussed

Clean sweep

- Key stakeholders/ management led walk on the ramp to collect FOD and raise awareness amongst employees is done on a regular basis

Key Performance Indicators

- FOD on runway is kept as a KPI and being highlighted in RST and ASAG meetings

[15] Electronic communication dated 25 February 2015.

FOD initiatives

- FOD Safety Marathon
  - ✓ FOD marathon was jointly conducted with active participation from all stakeholders in 2010. A total of 3000 participants had attended the training session (in 16 days) where 3 sessions were done daily

- Safety Campaign during World Safety day
  - ✓ FOD as one of the highlights during the campaign
  - ✓ Concentrate on Airside operations and ARFFS

- FOD Safety campaigns by Airside operations in 2011 included:
  - ✓ Active participation from all stakeholders
  - ✓ Inaugural walk in the designated area with Vice President Operations
  - ✓ Every day FOD walk by stakeholders
  - ✓ Essay competition on the subject "How do I contribute to FOD management in the airport"
  - ✓ Spot quizzes throughout the airside and 65 token gifts issued

  Currently[16] the FOD Safety campaigns include:

  - ✓ FOD walks, essay competitions, poster competitions, Spot quizzes are organized as a part of safety campaign

- FOD campaigns by stakeholders:
  - ✓ Transguard[17] group employees have initiated their own FOD campaign with Dubai Police, which are performed at a regular intervals
  - ✓ Dubai airports – facility care team conduct weekly FOD safety drives
  - ✓ Other key stakeholders conduct their own FOD safety campaigns as well.

- FOD Training
  - ✓ FOD training is covered specifically during various sessions for Airside controllers during their competency checks
  - ✓ FOD is an integral part of the Annual Developing Plan (ADP) training with the assessment on ADP covering FOD topics
  - ✓ dnata[18] has its own training and FOD is a part of the syllabus.
  - ✓ FOD is highlighted by various entities during their internal trainings.

- FOD statistics

[16] Electronic Communication dated 26 February 2015.
[17] The Transguard Group, is an Emirates Group company, that was established in 2001 and business support services providers in the U.A.E. region. It is a company that provides fully outsourced manpower for a range of solutions, from the supply of skilled and semi-skilled workforces. The company supports a wide range of industries including the construction, facilities management, aviation, hospitality and retail markets.
[18] dnata is a company providing the ground handling, cargo and logistics at Dubai International Airport.

- ✓ Of the 15 FOD observations on runway in 2011, 12 were aircraft related (6 aircraft tires and 6 aircraft parts) and 3 were vehicle related. Most of them were picked during regular inspections.
- ✓ The number of FOD on runway incidents have dropped from 1.14 per 10,000 movements in 2010 to 0.34 per 10,000 movements in 2014.

- FOD Policy
  - ✓ In 2011 the FOD policy was formulated to ensure better understanding of FOD concerns by stakeholders. Currently a detailed FOD policy for Dubai airports was circulated and is now a part of the Safety Management Systems Manual.

- Airside Operation Directive on FOD
  - ✓ Currently AOD highlighting the Zero tolerance towards FOD on Dubai airports has been communicated to all.

- FOD management on construction sites
  - ✓ Clear directives to contractors on FOD management at construction sites (FOD bins/ sweepers/ inspections).

- Other actions in 2011 were:
  - ✓ Cleaning schedule of GSE roads and maneuvering areas is being reviewed by AO team.
  - ✓ FOD safety campaigns being organized to improve awareness.

- ✓ Currently ongoing actions are :
  - ✓ Separate budget has been allocated to improve cleaning frequency in airport and awaiting approval.
  - ✓ Follow up GSE road repairs with ES/ EP to prevent FOD generation from vehicles.
  - ✓ Elaborate safety campaigns on FOD are being planned for the year
  - ✓ Award individuals/ company/ on FOD initiatives during HSSE awards
  - ✓ Review frequency of FOD removal from FOD bin/ Galley waste bin from stands and increase frequency as required
  - ✓ Review use of wind barrier and netting to restrict the movement of air borne FOD in DXB
  - ✓ Review provision of FOD cages on stand
  - ✓ Reemphasize the requirement of Pre arrival pre departure FOD checks with staff

APPENDIX C

A Concorde[19] registered F-BTSC, (On 25 July 2000), crashed in the commune of Gonesse (95) shortly after takeoff from Roissy Charles de Gaulle aerodrome. The airplane was undertaking charter flight AFR 4590 to New York. The one hundred passengers, nine crew members and four persons on the ground were killed. The accident was caused by FOD; in this case a piece of titanium debris on the runway which had been part of a thrust reverser which fell off from a McDonnell Douglas DC-10 that had taken off about four minutes earlier. All 100 passengers and nine crew on board the flight, as well as four people on the ground, were killed.

A B732, Pekanbaru Indonesia[20], 2002 (On 14 January 2002, a Boeing 737-200, attempted to complete a daylight take off from Pekanbaru, Indonesia without flaps set after a failure to complete the before take-off checks. The rejected take off was not initiated promptly and the aircraft overran the runway. The take-off configuration warning failed to sound because the associated circuit breaker was so worn that it had previously auto-tripped and this had not been noticed).

A Bombardier Learjet 36A[21], was taking off from Newport News/Williamsburg International Airport Va., (on March 26, 2007), when the crew heard a loud “pop”. Aborting the takeoff, the crew tried to control the “fishtailing” and activate the drag chute. The chute did not work and the Learjet ran off the runway, its tires blown. Airport personnel reported seeing rocks and pieces of metal on the runway, after the accident. The NTSB indicated that the Learjet accident was caused by Foreign Object Debris (FOD) on the runway. Failure of the drag chute contributed to the accident.

A B737, Southend UK, 2010[22] (On 21 Nov 2010, the crew had programmed the aircraft’s Flight Management Computer (FMC) for a maximum thrust takeoff from Runway 24 at Southend Airport. As the aircraft taxied out, ATC changed the runway in use to Runway 06. The FMC was re-programmed but an incorrect ‘assumed’ temperature was entered, resulting in too great a thrust reduction for the runway length available. Although the aircraft became airborne before the end of the runway, had the takeoff been rejected just before V_1 there would have been insufficient runway remaining within which to stop).

B738, Lyon France, 2009[23] (On 29 August 2009, a Boeing B737-800 departed the side of the runway during take-off but then regained the paved surface after sustaining damage from

[19] Downloaded from : http://www.bea.aero/en/enquetes/concorde/concorde.php , date 20 January 2015
[20] Downloaded from : http://www.skybrary.aero/index.php/Rejected_Take_Off date 18 January 2015
[21] Downloaded from : http://aviation-safety.net/database/record.php?id=20070326-0 , date 20 January 2015
[22] Downloaded from: http://www.aaib.gov.uk/publications/bulletins/october_2011/boeing_737_76n__5n_mji.cfm date 21 January 2015.
[23] Downloaded from: http://www.bea.aero/docspa/2009/7t-k090829/pdf/7t-k090829.pdf , http://www.bea.aero/docspa/2009/7t-k090829/pdf/7t-k090829.pdf , http://www.skybrary.aero/bookshelf/books/2762.pdf , date 21 January 2015.

obstructions, completed the take off without further event and continued to destination. Damage to one of the engines, to tires and to two lights was discovered at the destination. ATC remained unaware of the excursion until the Operator asked its representative at Lyon to ask the airport to carry out a runway inspection).

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